JULY 1956

Product Engineering

THE McGRAW-HILL MAGAZINE OF DESIGN ENGINEERING

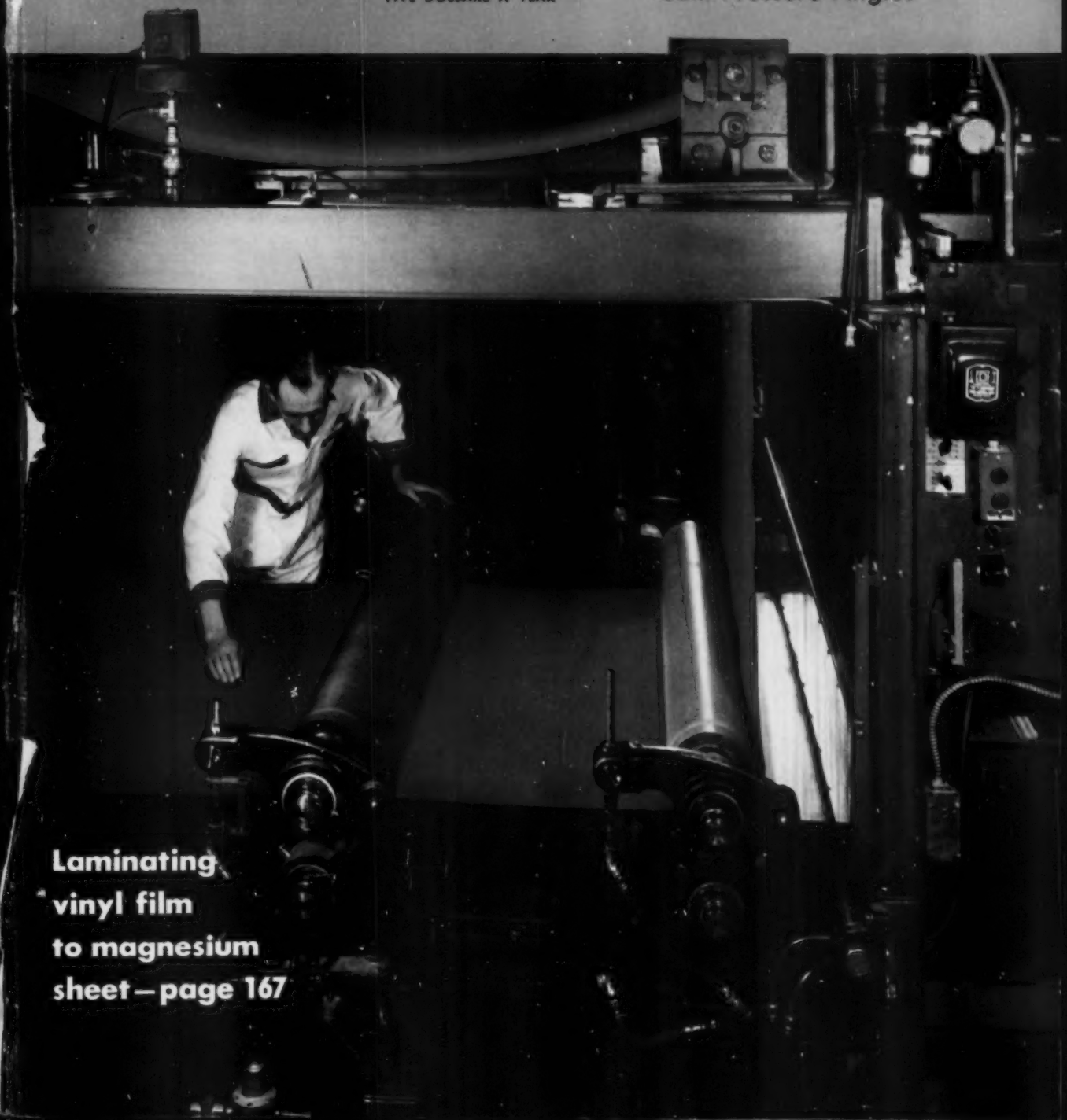
FIVE DOLLARS A YEAR

Functional design of
Hydraulic Circuits

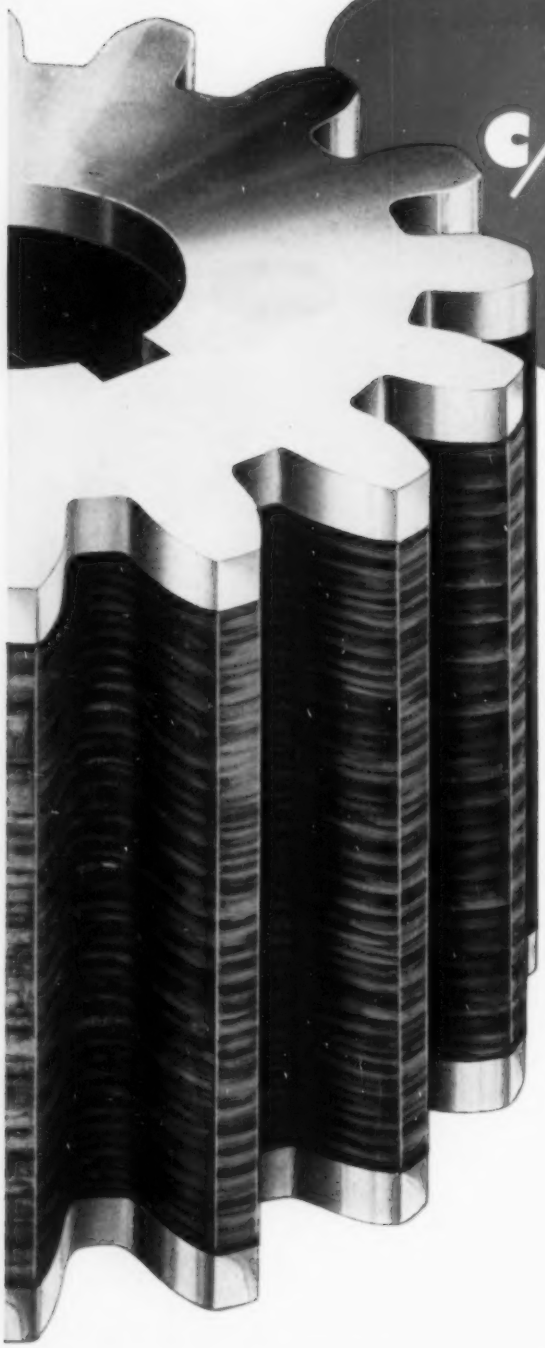
Constant Modulus Alloy

Electroforming Methods

Cam Pressure Angles



Laminating vinyl film to magnesium sheet—page 167



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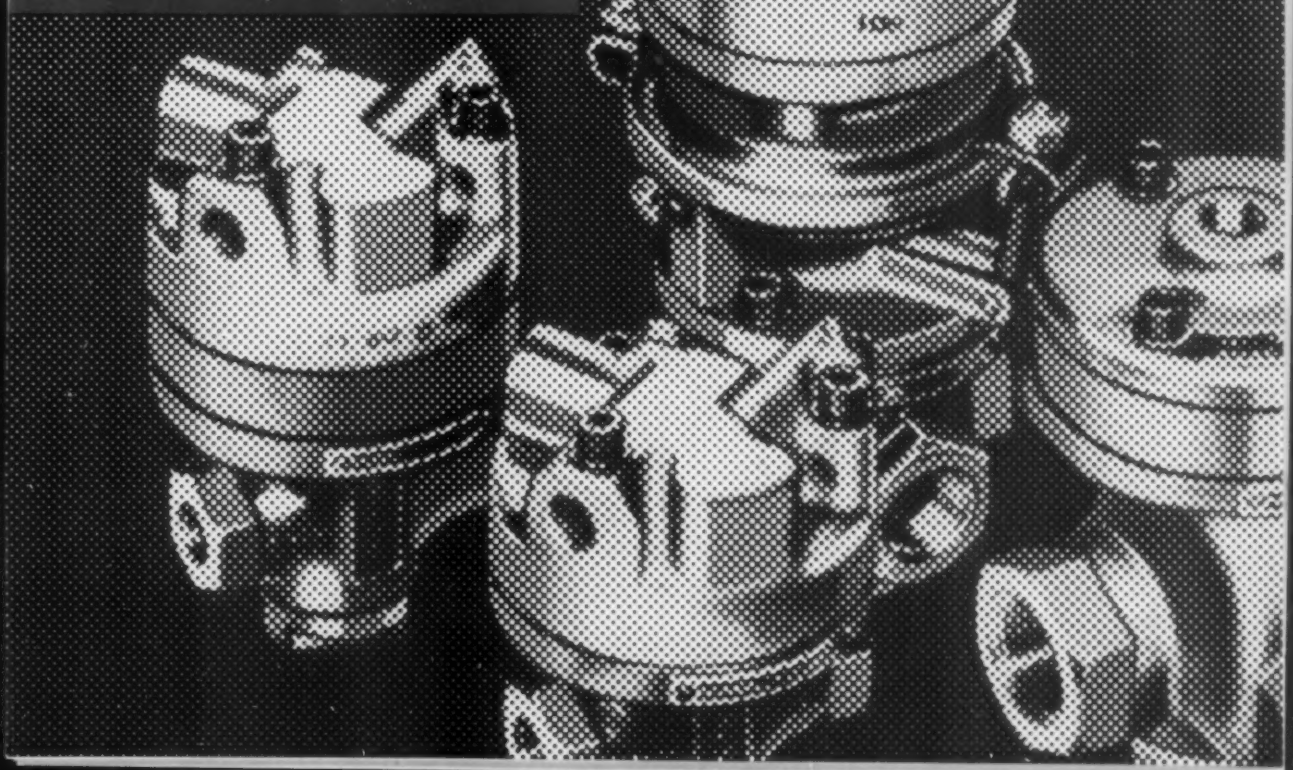

Look into REVERE Phosphor Bronze – it pays RAVENNA to use it!

This Moen Single Handle Mixing Faucet contains an anchor disc and an anchor washer, both stamped out of Revere Phosphor Bronze Strip. These are small parts, but in a fine product such as this faucet, high quality metals must be used throughout. Here is a condensation of the manufacturer's experience with the phosphor bronze:

Anchor Disc: • Standard punching speed maintained. • No pre-straightening off the arbor for the automatic punching process. • No excessive die wear. • Corners are sharp and clean; no de-burring needed. • Natural mill finish is better than they could achieve by tumbling or burnishing. • High tin content means no lubrication is required; they call it "silent brass."

Anchor Washer: • Have not had a single surface failure. • Dry tumble to de-burr. • Good fatigue characteristics and no obvious signs of corrosion.

Revere offers several types of phosphor bronze, each with slightly different characteristics. In addition to this alloy, Revere also supplies Ravenna with round and octagonal leaded brass tube and free-cutting brass rod, for use in various parts of the valve. We will be glad to collaborate with you on selection of just the right forms of the correct alloys for your products, present or projected. See the nearest Revere Sales Office.

Moen Single Handle Mixing Faucet, made by Moen Valve Co., Division of Ravenna Metal Products Corp., 6518 Ravenna Ave., Seattle 15, Wash.

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"The Revere Four-Way Service" is a 16 mm. sound motion picture in color, educational and informative. If you haven't seen it, write nearest Revere Office.

Product Engineering

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The McGraw-Hill Magazine of Design Engineering

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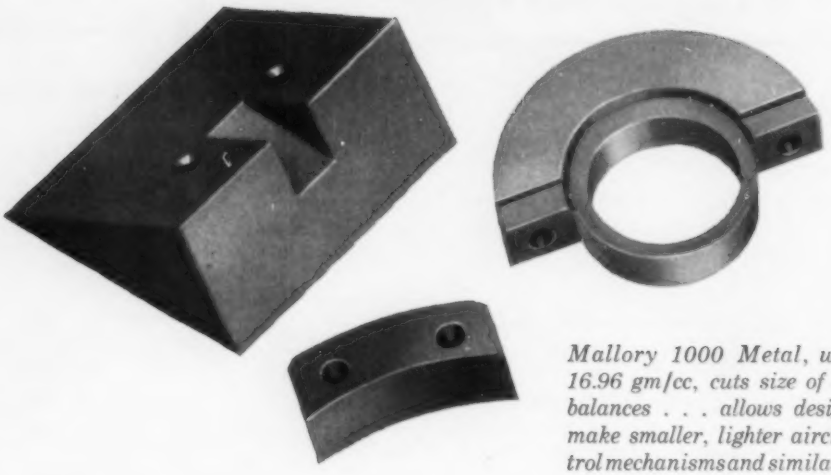
MALLORY



Mallory 1000 Metal, weighing 16.96 gm/cc, cuts size of counterbalances . . . allows designers to make smaller, lighter aircraft control mechanisms and similar devices.

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For information on titanium developments, contact Mallory-Sharon Titanium Corp., Niles, Ohio

THIS MONTH'S COVER

This machine, developed by Clad-Rex Steel Co., in Denver, laminates vinyl films to magnesium sheets using Marvibond adhesive, a product of Naugatuck Chemical. Bond has sufficient strength to permit heavy forming and drawing operations, as described in the article starting on page 167.

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Developments

To Watch

BEARINGS WITHOUT LUBRICATION. . . .

. . . . are being predicted as a result of the successful application of teflon to an automobile ball-and-socket suspension joint. Key to the development is the double weaving of the teflon fiber with a backing of nylon or cotton. This fabric is then laminated with cotton-reinforced phenolic resin and formed into a cup which lines the socket. The metal parts are coated with a special grease to prevent corrosion. The joint is assembled, and the preformed bearing is molded in place to give a spherical contact between the ball stud and the bearing. The joint is then sealed. Preliminary tests have shown that the bearings will last the lifetime of the automobile without lubrication or other maintenance. The manufacturer of the bearing, the American Metal Products Co., Detroit, Mich., claims that the teflon bearing reduces the amount of friction by more than 50 per cent in comparison with standard lubricated suspension joints. Tests conducted under a compression load of 1000 psi showed that a force of 9.4 lb was required to move the standard joint, and 7 lb to keep it moving after starting friction was overcome. The same test on new teflon joint showed the force required to be 2.1 lb initially, dropping to 1.2 lb. The melting point of teflon is over 600 F. Other applications of teflon fiber under development are: rod ends for special controls and self-aligning bearings; cylindrical parts such as seals, bushings, pistons, and sleeve bearings for all types of machinery. DuPont & Co., Inc., originator of teflon, cooperated in the development of the bearing.

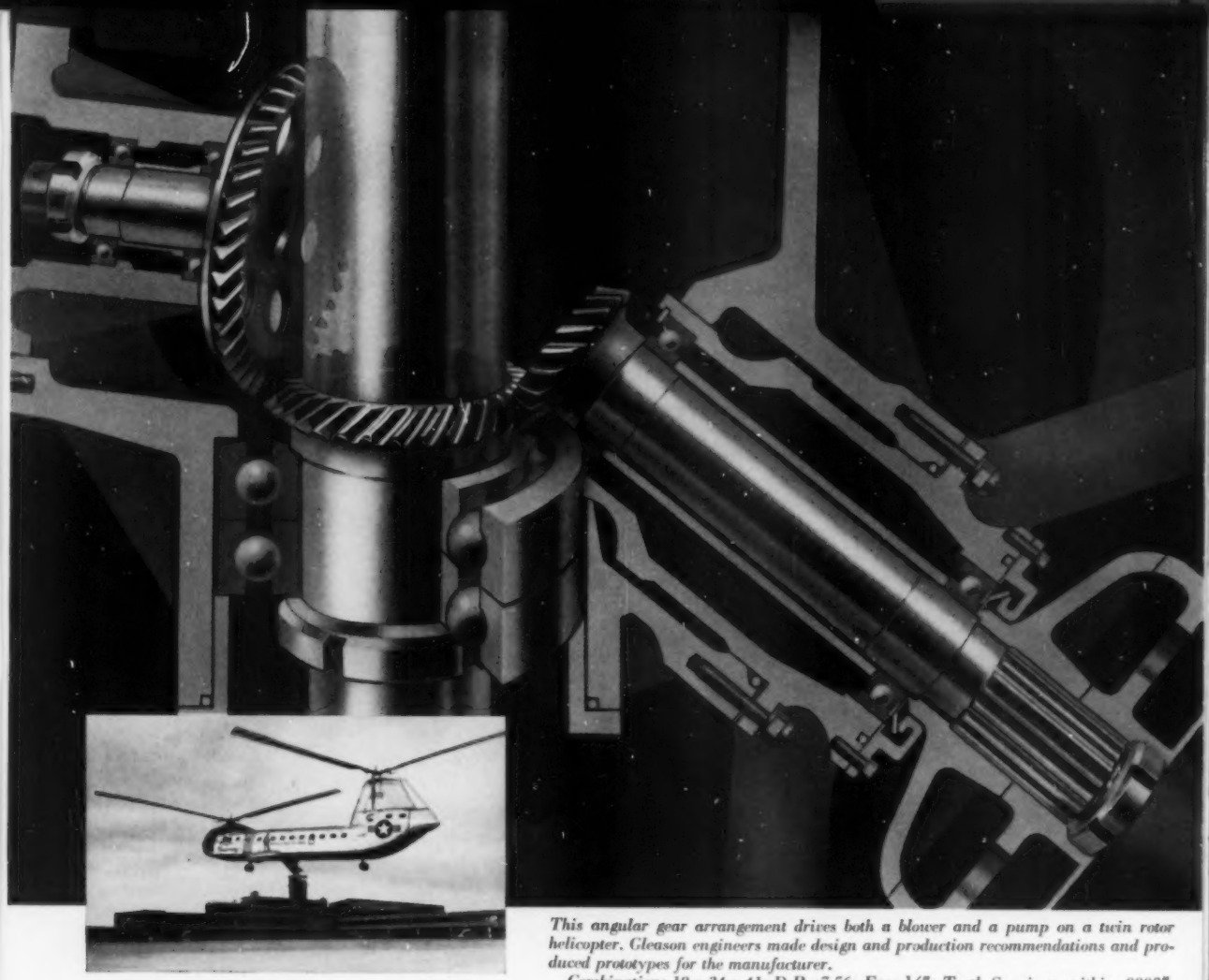
TWO NEW HIGH TEMPERATURE ALLOYS. . . .

. . . . for aircraft and industrial gas turbine use have just been announced by the International Nickel Co., 67 Wall St., New York 5, N. Y. Inconel 700 is an age-hardenable nickel-cobalt-chromium alloy with about 50 per cent nickel and 30 per cent cobalt, and was developed for forged aircraft gas turbine blades at temperatures up to 1650 F. The mechanical properties of this new alloy at 1650 F are similar to those of Inconel X at 1500 F. It is being produced as hot rolled rounds in the size range of $\frac{5}{8}$ to 2 in. dia. The second alloy is Incoloy 901, a nickel-iron-chromium alloy for components requiring high creep and rupture strength in the 1000-1400 F range. The alloy has 40 per cent nickel, and is close enough to ferritic alloy steels to permit the two to be joined without allowance for thermal expansion.

AN IMPROVED ELECTRONIC CIRCUIT BREAKER. . . .

. . . . with a sensitivity of response to below 1 per cent variation in line current, and operation within one cycle of line frequency, has been designed by K. G. Bahr & I. C. Leach, 11 Manningham

(*Continued on page 7*)



This angular gear arrangement drives both a blower and a pump on a twin rotor helicopter. Gleason engineers made design and production recommendations and produced prototypes for the manufacturer.
Combination: 18 x 34 x 41; D.P. :7.56; Face ½"; Tooth Spacing—within .0003".

You can solve your angular power transmission problems, too!

The designers of this gear unit achieve greater flexibility within a limited amount of space by placing the drive shafts at an angle and using one source of power to drive two auxiliary units.

Perhaps a similar gear drive would make your product designs more flexible. Such bevel gear drives permit a more compact design requiring less weight and the ability to carry higher loads.

Our engineers are ready to help you work out applications for bevel and hypoid gears—just as they helped the helicopter manufacturer with the design illustrated above.

We recommended the proper gear sizes and reviewed the mountings and lubrication for the drive. Then we produced and tested prototypes of the unit.

If you would like to discuss an application with one of our representatives, please write. You will also find these Gleason Technical Handbooks helpful: 20° Straight Bevel Gear System; Spiral Bevel Gear System; ZEROL Bevel System.

GLEASON WORKS

Builders of bevel gear machinery for over 90 years

1000 UNIVERSITY AVE., ROCHESTER 3, N.Y.

Developments to Watch

Rd., Bulleen, Victoria, Australia. Measuring 8 x 5¼ x 3⅜ in., the device is fundamentally a sensitive electronically controlled relay to be connected to any external circuit by a low impedance transformer. For accurate operation, the input transformer differentiates the waveform to the control electrode giving a more constant firing angle. To offset sensitivity limitations from line fluctuation, a circuit of clamping diodes and a reference voltage tube was developed. Here, sensing of variations in line voltage permits corresponding adjustment in the tube triggering threshold. With transducers, it will respond to heat, light, sound, pressure.

NON-DEFENSE USES OF TITANIUM. . . .

. . . . as a result of the limited amount of the material now available, include fire walls and nacelles in commercial aircraft, because of its heat resistant properties and low weight. Because of its corrosion resistance, other uses are for filter press parts exposed to nitric or chromic acid, ferric, cupric, or sulfate ions (other than straight sulfuric acid). These applications will cost only about three times as much as stainless with 56 per cent of the weight and 15 times the life. Titanium is being used in steam jet diffusers in place of cast iron; in jacketed kettles for food processing; marine hardware; rocker arms in engines; and high speed centrifuges.

COLUMNAR GRAIN GROWTH IN ALUMINUM CASTINGS . . . .

. . . . can be prevented by applying low frequency vibrations to the castings during solidification according to the results of tests made at Armour Research Foundation, of the Illinois Institute of Technology. Since the conditions conducive to such columnar growth in the center of the castings are associated with a steep thermal gradient, a cylindrical mold with a water cooled metal base plate was used in the studies. The vibrations produced had a frequency of 60 cps, and an amplitude not over 0.030 in., which corresponds to a 5G peak acceleration. There was a minimum section below which vibration had little effect. With 2S cast at about 1400 F, this was about 3 in. It has not been determined for other alloys.

CONVENTIONAL AIRCRAFT DE-ICERS ON THEIR WAY OUT . . . .

. . . . and will be replaced by chemical compositions that effectively prevent ice accumulation on wings, according to tests being conducted for the Air Force at the Armour Research Foundation of the Illinois Institute of Technology, Chicago 16, Ill. Significance of the development is cost and weight reduction in aircraft. The de-icers used include freezing point depressants and heat releasing chemical compositions that can be brushed or sprayed on, or applied in the form of tape. One composition permits the pilot to get rid of the ice that has built up.

HIGH TEMPERATURE MAGNESIUM ALLOY . . . .

. . . . containing 3 per cent thorium and ¾ per cent zirconium is reported by Marquardt Aircraft Co. to have mechanical properties which make it useful in the temperature range of 500-600 F. Weighing one-fourth as much as steel, the alloy retains its high strength and elastic modulus at temperatures of 600 F, has good creep resistance, can be heat treated, and is weldable. In forming, it is heated to 600-700 F. On aircraft engines it is being used on the diffuser, the combustion chamber, fuel pump, flame holder, and exit nozzle of ram-jets.

(*Continued on page 9*)

Now! VINYL foam ...so versatile, it can be varied to meet your needs!

because it's made of **Firestone**

A totally new foam product with exceptional durability, economy and, most of all, *versatility*—became possible through the development of the vinyl plastisol resin. (Exon 654 in the Firestone line of vinyls.)

Vinylfoam is produced by the Elastomer process, using Exon 654 as the base resin.

Molded in cored or slab form, it can be modified at no extra cost to be as soft or as firm as you need, as light or as heavy, as thick or as thin, as resilient or as "dead."

It can be electronically heat-sealed without affecting any of its properties.

Exon 654 makes Vinylfoam exceptionally resistant to abrasion, corrosion, flame, aging, moisture, tearing and chemical action. With maximum dimensional stability, it resists oxidation, hardening and drying out.

It can be embossed, die cut, split or skived; molded directly onto textiles and most synthetics, and onto vinyl sheeting or film in continuous lengths. Mutual surface impregnation forms a homogeneous bond.

Vinylfoam gives products in almost every field new comfort, safety, durability. Vinyl's economy makes them cost less, sell easily.

VERSATILE VINYL RESINS
engineered answers to industry's needs

Firestone Plastics Company supplies the plastisol resin for Vinylfoam . . . does not make the finished foam itself.

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Developments to Watch

EPOXY RESINS IN TAPE FORM . . . .

. . . . are available for electrical insulation from Minnesota Mining and Mfg. Co., St. Paul, Minn. Tape X-1035, a glass cloth, and tape X-1045, a non-woven polyester, are impregnated with a thermosetting epoxy resin. The tapes meet Class B electrical insulation performance requirements, which uses include: coils or conductors; insulating field windings by curing them in their slots; wrapping torroidal windings; forming channels of L and V shapes; and anchoring transformer leads. The X-1045 polyester mat is coated to a nominal thickness of 14 mils. Dielectric strength is in excess of 1000 V per mil, and volume resistivity is 10^{12} ohms at 96 per cent RH. It has an elongation of 45 per cent which can be applied to produce a shrinkage on cure. The 4 mil, X-1035 glass cloth is coated to 14 mils and has the same dielectric strength and volume resistivity. Complete cure for the tapes requires an average of 2 hours at 275 F.

A PRECISION METAL CASTING TECHNIQUE . . . .

. . . . using one piece glass powder molds is similar to the lost wax investment casting technique in some respects; but it eliminates completely the need for investment material and containers, de-waxing ovens, power equipment to move the investments, and all knockout equipment. Called the Glascast disposable pattern process, it was developed by the Corning Glass Works, Corning, N. Y. The lightweight molds are made by dipping a wax pattern into a slurry of 96 per cent silica glass powder, and after drying the assembly, dipping and coating it several times to build up the mold shell to $\frac{1}{8}$ to $\frac{1}{4}$ in. The assembly is then fired (removing the wax at the same time) and the mold is ready for casting. The process was developed for casting close tolerance precision parts of high temperature alloys. The molds can take metal pouring temperatures up to 3300 F, with the low dimensional change and lack of firing shrinkage offering tolerances of ± 0.005 in. The castings have surface finishes of 20 to 40 microinches. Metal contraction after casting causes the mold to crack off. Corning says that the process is adaptable to assembly line use, with an average of 24 hr between pattern makeup and casting time. In a test run of jet engine turbine blades, less than 10 per cent were rejected.

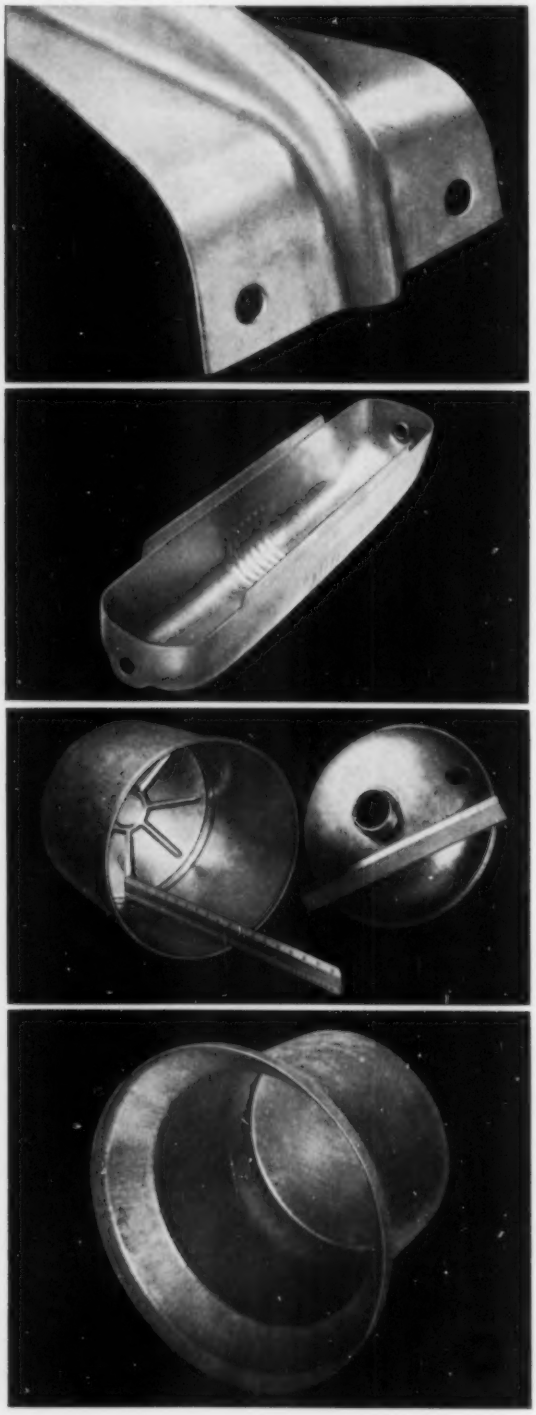
AND IN ADDITION . . . .

. . . . Ford Motor Co. is diversifying into the electronics and nucleonics field for defense and peacetime application, with the development of their new subsidiary Aeronutronic Systems, Inc.; the nucleus of the company consists of the scientists and engineers who formed Systems Research Corp. after a heated dispute with Lockheed Aircraft caused their resignation (P. E., Feb. 1956, p 208). . . . A new device for record players is a servo driven straight line arm which keeps the arm parallel to the record groove at all times, eliminating side pressure on the needle, and reducing wear and distortion; developed by the Rabinow Engineering Co., 7212 New Hampshire Ave., Washington, D. C., it has a brushless clock motor that drives a lead screw which keeps the arm in correct relation to the groove. . . . Technetium, a very rare, radioactive metal is being used in experimental work at the Oak Ridge National Lab. to study the "whys" of corrosion. . . . A new process known as margin plating, in which only the narrow margins of the steel plate that form the soldered side seams of the cans are tinned, may cut the tin use in cans for packaging foods by 98 per cent, according to the American Can Co. . . . A new chassis and suspension system will drop the height of the 1957 Cadillac by 4 in.; because of a 14 in. wheel, the Nash, Hudson, and Rambler will be down 2 in.; Chryslers will be down 3 in. In late 1957, Ford and Chevrolet hope to have a "retractible hard top".

Here's a 20-year service record of

LOWER COSTS, EASIER SALES FOR USERS OF DEEP-DRAWING ARMCO ZINCGRIP STEEL

Products such as these have been made of Armco ZINCGRIP Steel since 1936.



For more than 20 years drawn and severely formed parts like these have been made of Armco ZINCGRIP Steel at less cost in the shop. The reasons are: no flaking or peeling of the special hot-dip zinc coating, elimination of finishing after fabrication, and the production advantages of ZINCGRIP coils. ZINCGRIP also helps boost sales because of its attractive appearance and unbroken protection against rust.

In 1936, when Armco introduced ZINCGRIP, the *first* continuously zinc-coated sheet steel, designers and production men found it difficult to believe that a zinc-coated sheet could be drawn without damage to the coating. But a few trials—reverse draws, lock seams and roll forms—proved that the special coating on ZINCGRIP didn't flake or peel.

Proved in 20 Years' Service

More than 20 years' experience in hundreds of manufacturing plants has established this fact: *Anything that can be done with sheet steel can be done with Armco* ZINCGRIP. You don't have to baby it in the shop, and its formability gives you much greater freedom in design.

Twenty years have also proved that ZINCGRIP resists yellow rusting longer than ordinary galvanized. This, plus the smooth, attractive surface of ZINCGRIP, makes products easier to sell and keeps your customers satisfied.

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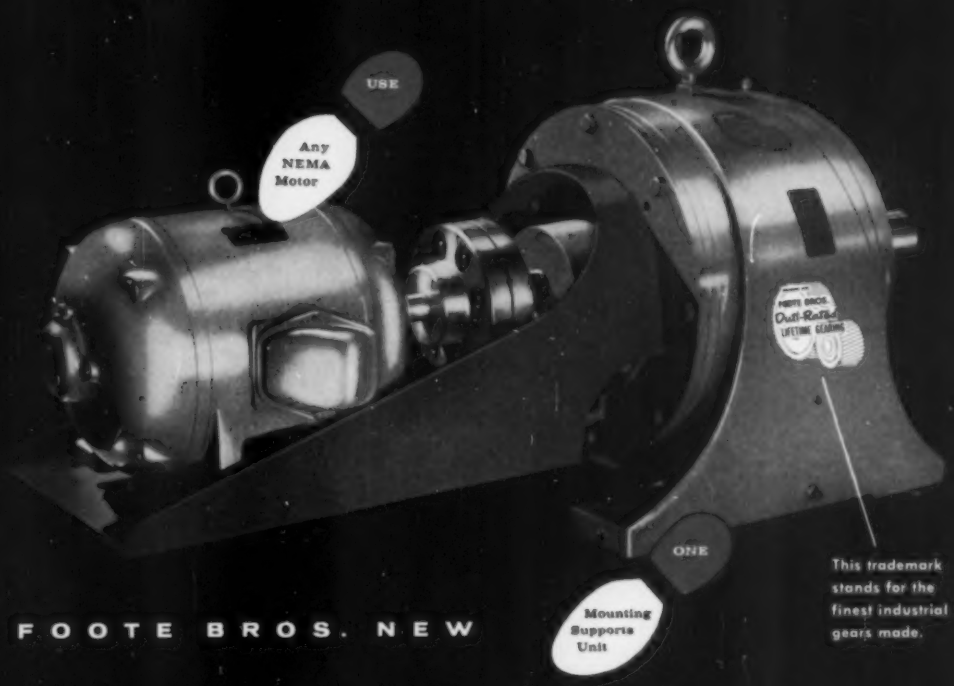
1826 Curtis Street, Middletown, Ohio • Sheffield Steel Division • Armco Drainage & Metal Products, Inc. • The Armco International Corporation

Basic Idea

SOLVES MANY REDUCER MOUNTING PROBLEMS



FOOTE BROS. NEW

Line-O-Motor Drive

One base supports both speed reducer and motor in this simple, practical and foolproof mounting system . . . Now you can use standard N.E.M.A. motors and make change-overs in minutes—reducing both costly down-time and motor inventory.

Line-O-Power motorized drive solves many old problems . . . and opens new fields of advanced design for new applications. Available 1-75 H. P. for all Service Classes—Horizontal, Vertical, and Vertical Extended with Foot or Flange mounting—Double or Triple Reduction units available in Ratios from 5.06:1 to 238:1.

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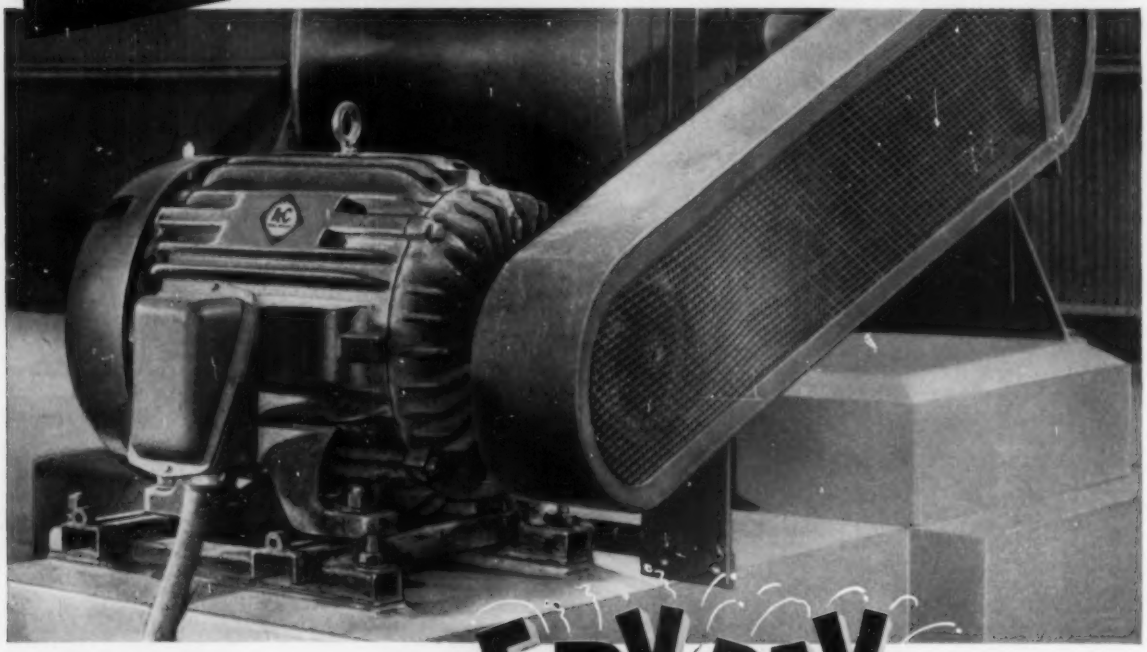
Write for your Line-O-Motor Catalog today

There's **MORE** Cooling Surface in these deep-ribbed **MOTORS**



No Day is FRYDAY

with these Allis-Chalmers MOTORS

● Frying of insulation is impossible under normal conditions with the extra-large cooling surface of Allis-Chalmers rib-type TEFC motors. The result — longer motor life assures you "repeat" business from your customers.

The engineered partner of A-C motors is Allis-Chalmers control.

Get Complete Information

To get the most from machinery you build, specify Allis-Chalmers components. Discuss your particular application with your nearby A-C district office, or write Allis-Chalmers, General Products Division, Milwaukee 1, Wisconsin.

ALLIS-CHALMERS

A-5053

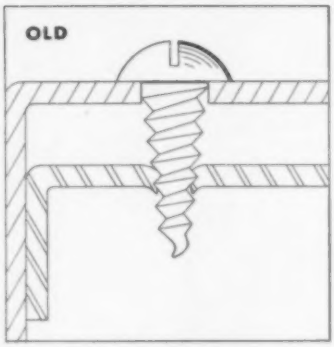
B.F. Goodrich Rivnut

provides shockproof nutplate, saves time and money

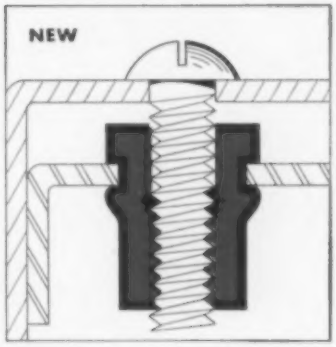
B. F. Goodrich Rivnuts provide accurate, shockproof nutplates in one, quick operation. They eliminate nuts, welding, tapping, clinching. They are particularly suited for blind applications where other methods of fastening are impossible. They give a tight, dependable seal. And save man-hours, too, because one operator can install a Rivnut in seconds.

Just as BFG Rivnuts speeded up output and eliminated assembly and service problems for the Graef Storm Window Co. (SEE PICTURES AT RIGHT), Rivnuts are uniquely successful when used in any thin sheet metal. They are the only method of fastening available that gives 6 clean threads for attachment. They can even be installed *after* enameling.

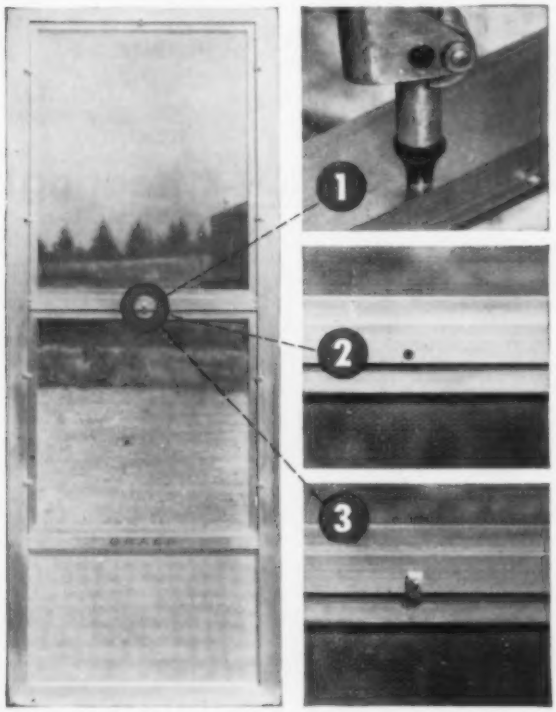
If you're looking for a fastener that can improve your product and cut production time, why not get the help of The B. F. Goodrich Co., Dept. PE-76, Akron, Ohio.



USING SELF-TAPPING SCREWS. To attach insert clips to aluminum storm doors, the Graef Storm Window Co. considered a conventional method, tried self-tapping metal screws. They found that due to the softness of the aluminum, screws pulled out and enlarged the hole. A new hole had to be made or a larger self-tapping screw used. They could foresee service problems. When storm windows were changed by the user, the metal would pull or tear.



USING B. F. GOODRICH RIVNUTS. No assembly problems, no service problems, reports Graef. Rivnuts speed assembly—installing in door stiles takes only seconds. They provide a firm, accurate nutplate that does not loosen with shock or vibration. At least 6 threads are clean for attachment, eliminating any pulling or tearing of metal during assembly or later, when storm windows are changed by the user.



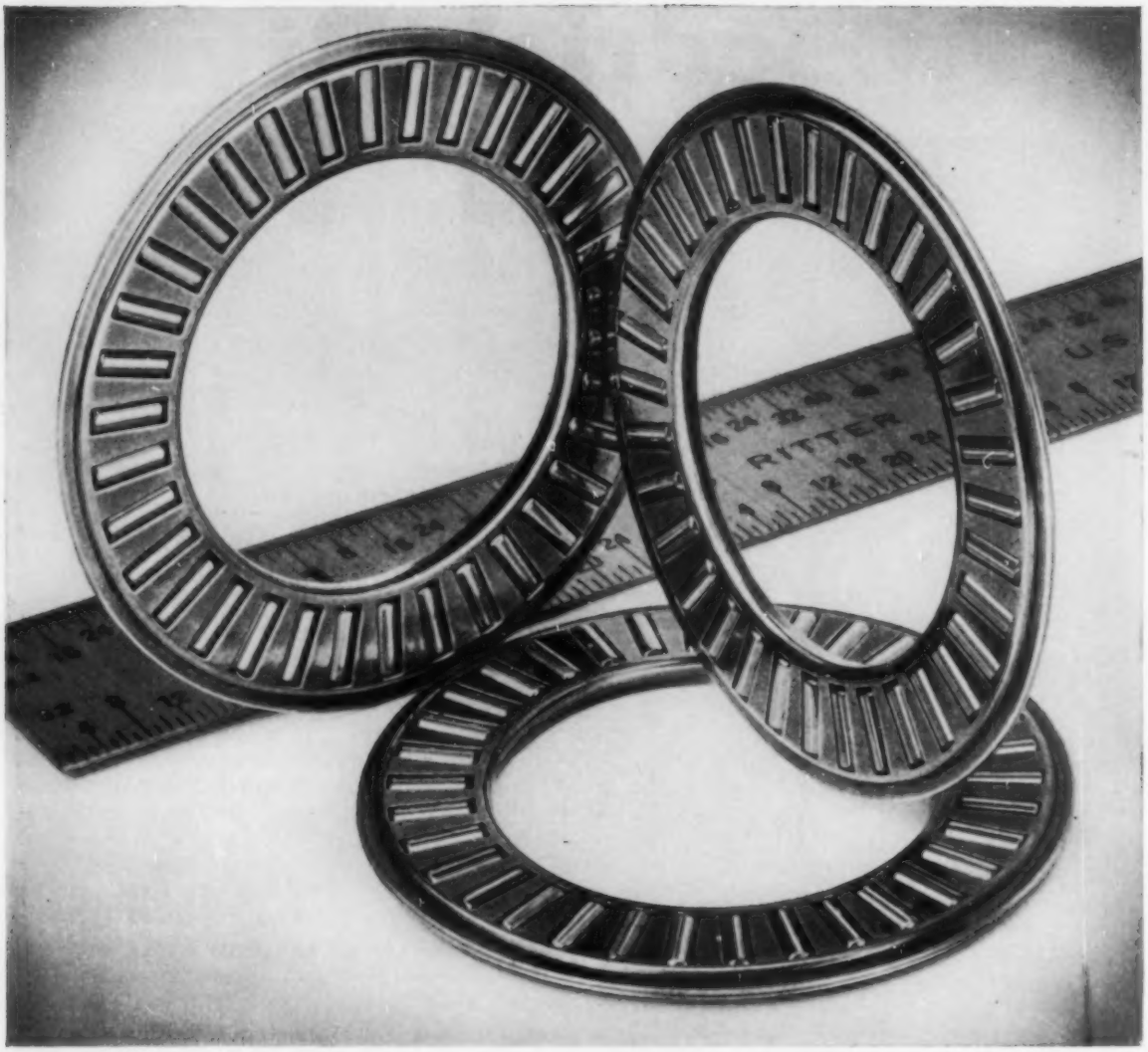
HOW GRAEF SPEEDS ASSEMBLY USING RIVNUTS
(1) Rivnut is inserted in blind aluminum door stile. Heading tool forms bulge inside in one, quick operation. (2) Rivnut fits smoothly, tightly. Six clean threads provide attachment for (3) bolt and retaining clip which holds screen insert. Door slamming, change of inserts will not loosen the nutplate the Rivnut provides.

Send now for
FREE RIVNUT
Demonstrator

Demonstrates with motion how you can use Rivnuts to fasten TO and fasten WITH. Explains construction, simplicity of installation. Get your free copy today by writing to: The B.F.Goodrich Company, Department PE-76, Akron, Ohio.

B.F. Goodrich RIVNUTS

The only one-piece blind rivet with threads



Here's the **NEW** Torrington Needle **THRUST** Bearing!

Now designers have available a *needle bearing* exclusively for heavy *thrust* loads.

This compact Torrington Needle Thrust Bearing—only .0781" in cross section—is no thicker than an ordinary thrust washer. Yet it brings all the advantages of anti-friction operation at low unit cost for many .thrust applications.

Two mating retainer halves, highly accurate steel stampings, are securely joined to form a self-contained unit closed on OD and ID. The bearing can run directly on adjacent parts, hardened to act as races, or on economical hardened and ground flat races. The bearing is piloted on the retainer bore.

In any thrust application where low unit cost, high thrust capacity and compact design are primary factors, consider the Torrington Needle Thrust Bearing. Services of our Engineering Department are available to assist you with design and application.

Send for our new Bulletin, "No. 10—Torrington Needle Thrust Bearings," for full information.

Highly successful applications of the Torrington Needle Thrust Bearing have been made in automatic transmissions, governors, steering gears, bevel gears, hydraulic pumps, and torque converters.

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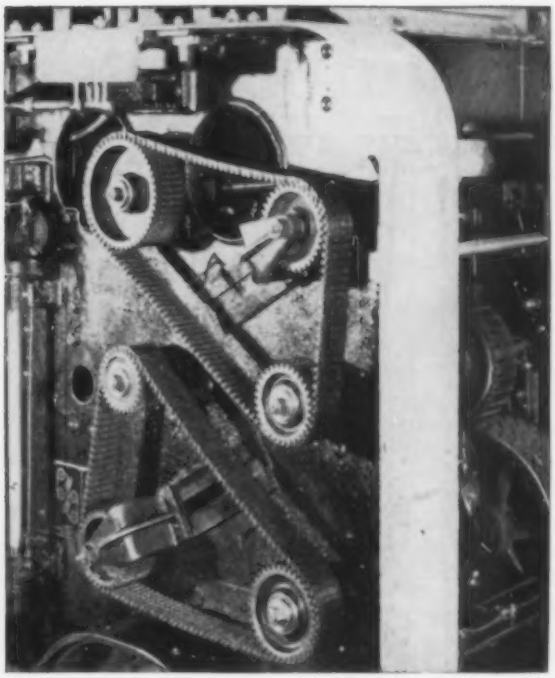
Torrington, Conn. • South Bend 21, Ind.
District offices and distributors in principal cities of United States and Canada

TORRINGTON BEARINGS

Needle • Spherical Roller • Tapered Roller • Cylindrical Roller • Ball • Needle Rollers

Drives for Small or Large H.P. For example, this tiny Link-Belt 3/16-in. pitch Silent Chain is widely used by top designers for positive, flexible fractional horsepower transmission at speeds ranging up to 9000 rpm.



Drives for High or Low Speed. High horsepowers and high speeds are delivered with the same trouble-free efficiency (over 98%) as on less severe service. Positive tooth-to-tooth action provides constant ratio for full productive capacity.

Big reasons why LINK-BELT Silent Chain

is specified for so many drives:

- Lower cost—often lower in first cost, always lower in ultimate cost.
- Longer life—trouble-free performance for 20 to 30 years is common.
- No dismantling machine or removing sheaves for repairs.
- Better than 98% efficiency.
- Maintained ratio assures full productive capacity.
- Slipless action assures a better product.
- Easy to install.
- Safe to employees—operates in oil-retaining casing.

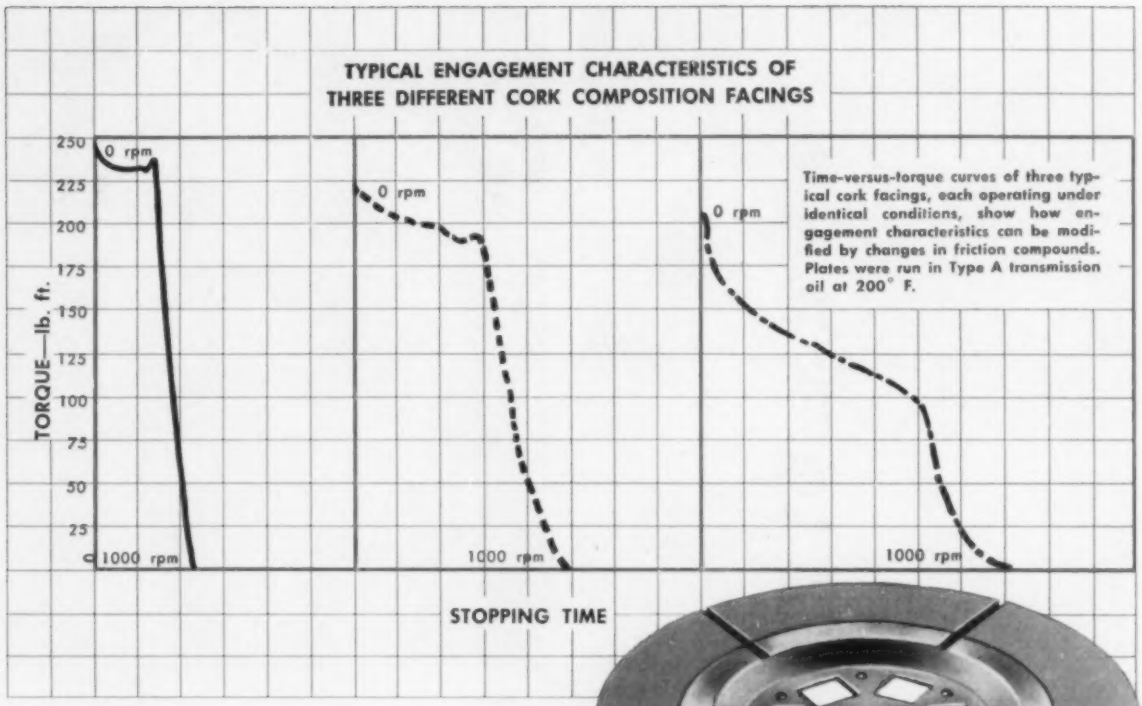
SILENT CHAIN is just part of the complete Link-Belt line. You can choose from all types and sizes of cast, combination, forged and fabricated steel, roller or silent chains—with matching sprockets. No matter what your drive or conveying needs, you're sure of getting the *right* chain for the job.

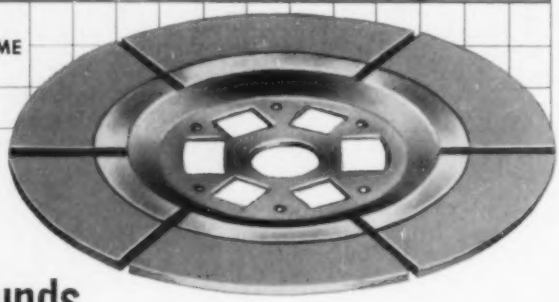
Get the complete Link-Belt Silent Chain story from Book 2425. Or send for Catalog No. 950 . . . a handy source for all the facts on industry's broadest chain line.

LINK-BELT

CHAINS AND SPROCKETS

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office, New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World.





CORK CLUTCH FACINGS:

How changes in cork compounds help you control engagement characteristics

A unique design advantage of cork facings in wet clutches is that engagement characteristics can be widely modified by controlled changes in the cork compound.

For example, you can specify an engagement that is smooth and shock-free—or one that is virtually instantaneous, depending on the needs of a particular design.

The unusual versatility of cork compounds is the result of skillful compounding of cork with a variety of rubbers and resins. For example, by varying the size of the cork particles, the kind and amount of binder, or the density of the composition, many different possible materials can be produced.

The chart above demonstrates how different performance characteristics can be obtained by such changes in the facing compound. As the curves indicate, there is a marked difference in the type of engagement, even though the three test materials were run under identical conditions.

This is typical of the wide range of operating characteristics that can be secured through careful compounding of cork friction materials. More information on this subject—along with helpful charts—is contained in the booklet offered at the right.

NEW 16-PAGE BOOKLET

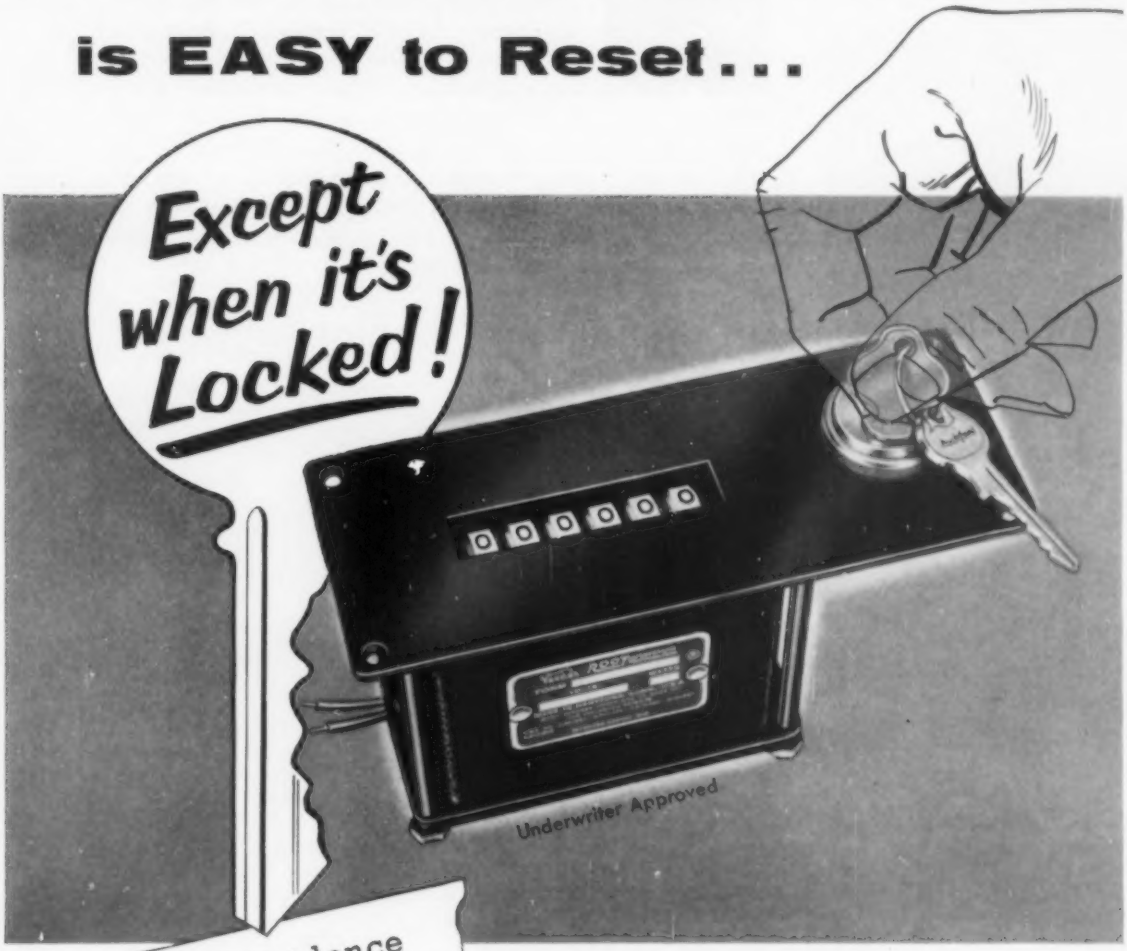
For more information on the design versatility of cork-compound friction materials, send for a copy of our new booklet, "Armstrong Resilient Friction Materials." It's free to industrial users. Write today to Armstrong Cork Company, Industrial Division, 7207 Irvin St., Lancaster, Pa.

Armstrong FRICTION MATERIALS

. . . used wherever performance counts

This NEW Magnetic Counter

is EASY to Reset...



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Designed for panel mounting where remote indication is required, this electrically operated counter is a compact package 5.5″ long, 2.1″ wide, 2.7″ high. Capacity: 1,000 counts per minute. Power consumption, 8 watts. Stocked in 110 and 220 AC and DC. Easy to reset, except when locked . . . then the sturdy tumbler-lock* puts the damper on tampering. Yet one turn of the key resets all 6 figures to zeros.

This new Magnetic Counter is one of the thousands of Veeder-Root standard and special counters . . . electrically, mechanically and manually operated . . . in daily use throughout the world in industry, business, science and medicine. You, too, can count on Veeder-Root . . . to help you count anything you need.

*National Lock Co. Lock No. 68-4837, Key D-428

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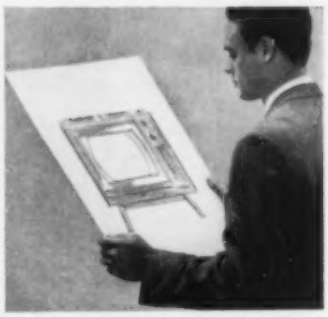
VEEDER-ROOT
"THE NAME THAT COUNTS"

Craftsmanship of the 20th Century

MONSANTO

Competition for tomorrow's markets imposes a heavy responsibility on the men who design for industry. In their constant search for ways to improve products within definite cost boundaries, many of them are working closely with plastics engineers in the custom molding industry. These pages report on how the unique properties of plastics helped RCA designers create an important component for a color television set. It is more than likely that custom molders, who are devoting their lives to craftsmanship in plastics, can contribute to solving some of your problems.

How RCA designers engineered a color television mask in Lustrex styrene plastic



DESIGN OBJECTIVES. Model sketches for the new RCA Victor* color television set called for a mask opening which would frame the kinescope in established size and permit a maximum viewing angle. A leakage path of six inches was required between high voltage bearing metal surfaces and adjacent points on the instrument subject to spectator contact. The mask had to be capable of supporting the front end of the kine in the cabinet. It had to combine utility with attractive appearance, in a color that would not detract from the color kine picture.

MATERIAL SPECIFICATIONS. After studying various materials RCA designers and engineers decided that a rigid mask molded of styrene plastic would best meet objectives. While a thin covering of insulation would have met specifications electronically, it did not offer the mechanical strength to support the kinescope properly. RCA experience with high-impact styrene masks for monochrome receivers had demonstrated their ability to support and locate the kine in position. At the same time they protected users from direct contact with it. By custom molding the mask in one piece, the part could be supplied ready for assembly and painting.

PRODUCTION ENGINEERING. RCA commissioned Amos Molded Plastics Company, Edinburg, Indiana, to supply the component. Tool design in the Amos plant was supervised by Dale E. Hickey, Chief Engineer. Monsanto Lustrex Hi-Test 88, a rubber-modified high-impact styrene plastic, was specified. Delivery of the kinescope masks began three weeks after the initial order was placed. Every design requirement was met satisfactorily by custom molding the mask of Lustrex Hi-Test 88.

THE FINISHED SET. The smartly designed cabinets of the new RCA Victor* color television set are exerting great consumer appeal in showrooms across the country. Smooth finish of the fluted plastic mask harmonizes richly with the high-styling of the complete unit.

This is one of hundreds of design and production problems which have been solved by utilizing the facilities of the plastics custom molding industry. These 20th Century craftsmen are available to manufacturers designing for greater efficiency and lower costs. As a major supplier of plastic resins, Monsanto is in a position to introduce you to custom molders who will put their skills to work for you. If you are considering a design change for your product line, be sure to investigate plastics. Write to Monsanto Chemical Company, Industrial Application Dept., Springfield 2, Mass.

Investigate the completely balanced line of Monsanto styrene compounds for particular applications, sold under the trade name . . .

LUSTREX® Styrene Plastic

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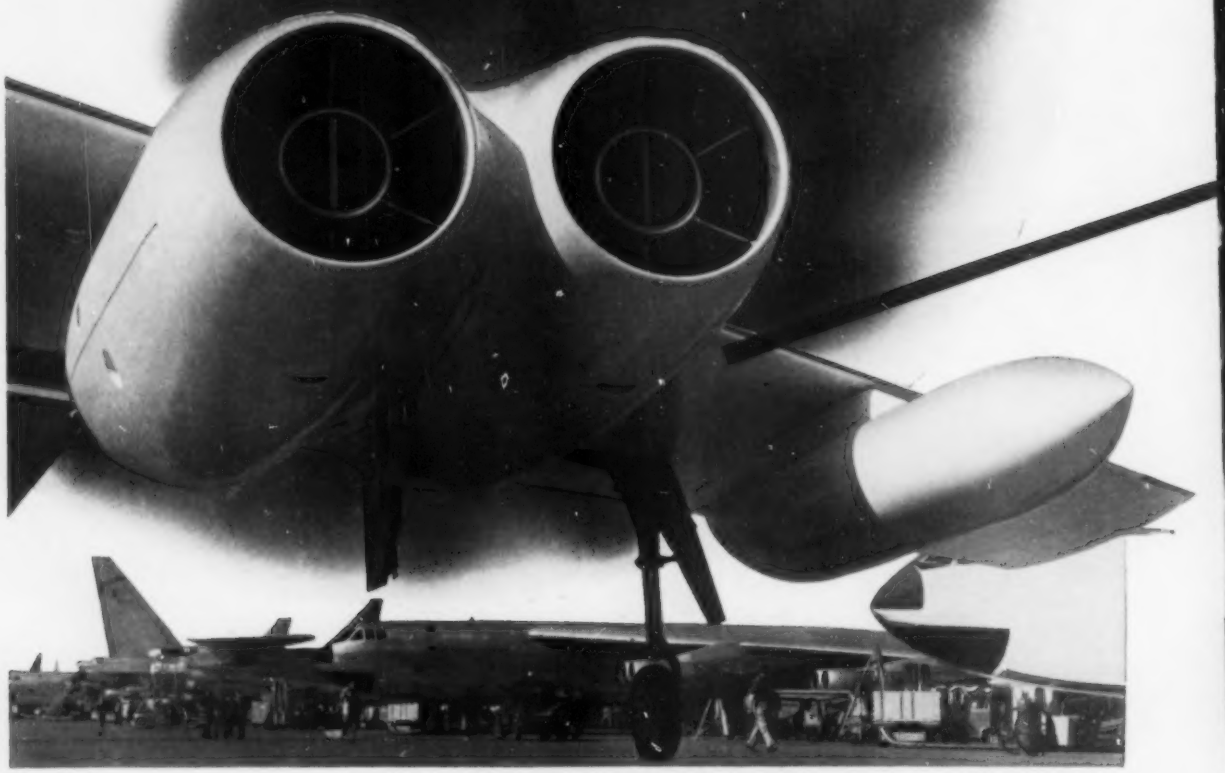
MONSANTO®

GRAPHITAR® is the main shaft seal
(CARBON-GRAPHITE)
PRATT & WHITNEY J57 turbojet

● Boeing's B-52 Intercontinental Bomber, the striking arm of our Strategic Air Command, is powered by eight twin-spool axial-flow turbojet engines manufactured by the Pratt & Whitney Aircraft Division of United Aircraft Corporation, East Hartford, Connecticut. These turbojets are in the 10,000 pound thrust class and in engines of this caliber, complete dependability is vital. One of the components of the J57 is a GRAPHITAR air/oil seal employed on the turbine main shaft which, naturally, is turning at high speeds. The GRAPHITAR seal also easily withstands the maximum operating pressures developed in the engine. The slots in the face of the seal shown on the opposite page (approximately ⅔ size) are for pressure balance and cooling. This Main Shaft Seal is just one of several GRAPHITAR seals used in the J57 engine. GRAPHITAR parts can resist such taxing physical conditions because they are strong, self-lubricating, and practically inert. GRAPHITAR has excellent wearing properties and cannot be corroded by most chemicals. Where the application is rough, and complete dependability important, GRAPHITAR is the engineering material to specify.



THE UNITED STATES

in the engine

● From the B-52 to the atomic submarine Nautilus, from automobile pumps to automatic toasters, GRAPHITAR is aiding the performance of literally hundreds of highly diverse products. This versatile engineering material is compacted under extreme pressure and fused at heats near 4500°F. It can be formed in relatively complicated shapes and ground to tolerances as close as .0005" for seals, bearings, vanes, piston liners, and many other parts. GRAPHITAR is self-lubricating . . . can be used where only steam or water are present. It is lightweight, strong, durable, chemically inert, and is virtually unaffected by extremes of heat, pressure, or temperatures.

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AN ALUMINUM COST

This cost savings story points the way to big economies for you!

PART I

CAMERA TRIPOD PART Converted from steel to aluminum. Cost savings per 1,000 parts . . . 38.4%

. . . based on material and production costs per part of $1.90 for steel and $1.17 for aluminum. Figures given do not include the cost necessary for plating had steel been specified. Because of aluminum's attractive finish and resistance to rust, anodizing was the only finishing operation required. This part is one of a number of different aluminum parts used in the camera tripod.

PART IV

BUSHING — Converted from brass to aluminum. Cost savings per 1,000 parts . . . 53%

Lower raw material costs were entirely responsible for these savings. Only 22 pounds of aluminum at $.56 a pound were required for 10,000 parts. Brass, however, required 67 pounds for the same job. At $.42 a pound, the total cost for brass was $28.14, less $4.58 for scrap recovery. Aluminum's total cost was $12.66 for every 10,000 parts produced.

PART V

WINDSHIELD WIPER KNOB INSERT — Converted from brass to aluminum. Cost savings per 1,000 parts . . . 24.8%

Because of the savings offered by aluminum, engineers tested it along with other materials for this particular application. They found aluminum would not only provide sufficient strength but would also take a slightly better knurl.

SEE "THE KAISER ALUMINUM HOUR" Alternate Tuesdays, NBC Network. Consult your local TV listing.

STORY IN FIVE PARTS

PART II
NOZZLE — Converted from brass to aluminum. Cost savings per 1,000 parts . . 24.9%
Set up time and labor costs were equal between brass and aluminum. But brass required 32.4 pounds for 1,000 nozzles while aluminum required only 10.66 pounds. The difference in material cost, therefore, was $7.86 or 24.9% saved per 1,000 parts in lots of 10,000.

PART III
INSERT — Converted from steel to aluminum. Cost savings per 1,000 parts . . . 35%
Cost savings on this part were due to lower machine time and not raw material costs. Aluminum's faster machinability permitted a two-third reduction in machine time per 1,000 parts.

HOW YOU SAVE WITH KAISER ALUMINUM

The five companies whose parts are shown here — like parts buyers all over the country — have discovered that Kaiser Aluminum stock can give them big savings and better quality.

You get *three times* as many parts from a pound of lightweight Kaiser Aluminum stock as from a pound of brass or steel. Thus, each part can cost far less.

And you often get *better* parts because aluminum provides a unique combination of useful advantages, including lightness with strength, handsome finish, corrosion resistance, good heat and electrical conductivity.

For more information or assistance, look for our local number in the classified telephone directory under the heading "Aluminum." Kaiser Aluminum & Chemical Sales, Inc., *General Sales Office*, Palmolive Bldg., Chicago 11, Illinois; *Executive Office*, Kaiser Bldg., Oakland 12, California.

Kaiser Aluminum

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Contains valuable detailed information for designers!

Technical Editor,
Kaiser Aluminum & Chemical Sales, Inc.,
919 N. Michigan Ave.,
Chicago 11, Illinois

Please send, without obligation, my copy of "Machining Kaiser Aluminum" which I understand is a hard-cover, library volume containing information of value to me when designing with aluminum.

Name _____ Position _____

Company _____

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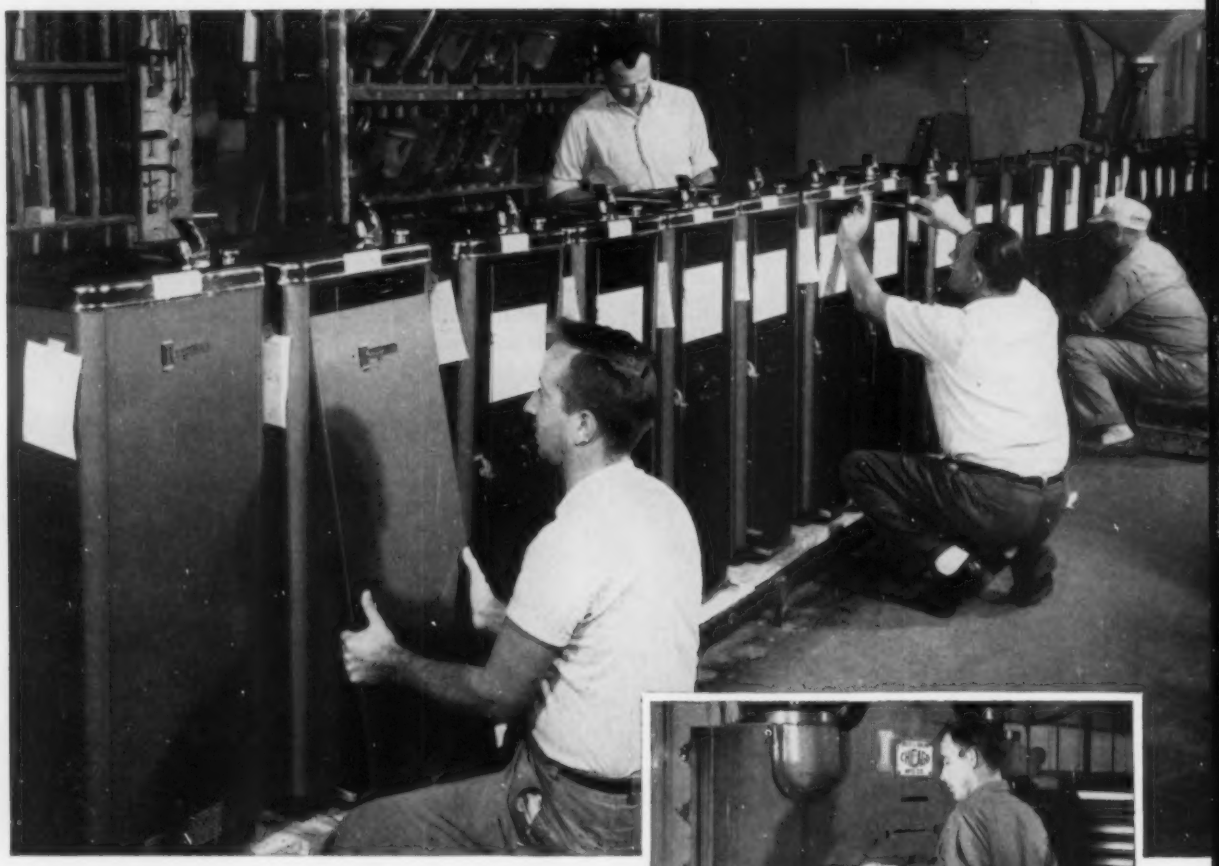
Republic Electro Paintlok® doubles



ONLY ONE COAT OF PAINT on Republic Electro Paintlok, results in a handsome, durable finish for these Temprite water coolers. In addition, Republic ENDURO® Stainless Steel is used for fountain tops to provide life-time beauty and sanitation.

SEVERE FORMING AND BENDING are shrugged off by chemically treated, electro plated zinc surface of Electro Paintlok. In fact, the phosphate coating itself acts as a lubricant for certain forming operations. Send coupon for full details.

REPUBLIC

REPUBLIC STEEL

World's Widest Range of Standard Steels

production of existing facilities

By using Republic Electro Paintlok instead of cold rolled sheet steel for their water cooler housings, Temprite Products Corporation of Birmingham, Michigan, actually double the output of their painting and drying facilities. How? Because only one coat of paint is used on these parts when fabricated from Electro Paintlok, and one pass through the drying oven is sufficient to produce a high-quality, long-lasting finish.

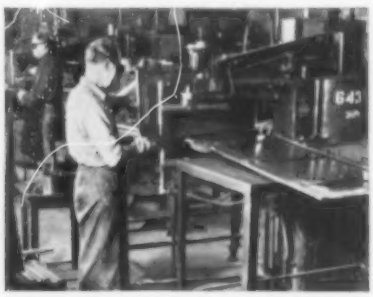
In contrast with this, uncoated sheets for this application required a prime coat before final painting. Temprite found, through experience, that the labor and material cost of the primer coat exceeded the extra cost of Electro Paintlok. Even more important, at today's level of demand *they could not maintain required volume of production when both a primer and final coat of paint had to be applied and dried.*

As a result, Temprite has standardized on Republic Electro Paintlok. And in addition to cost and time savings, they secure a higher quality finish as well. Even when scratched through, Electro Paintlok's chemically treated zinc surface continues to retard corrosion and effectively limits it to the point of original damage.

Add all of these advantages to the fact that Electro Paintlok is delivered from the mill in prime condition for painting and will not rust under approved warehousing conditions . . . and you can see why it will pay you to investigate its use wherever you have a paint adherence problem. Simply contact your Republic representative or mail the coupon for full information.

BUILT-IN SALES APPEAL for the Temprite Club Bar, four-beverage dispenser, is secured through the use of ENDURO Stainless Steel for all housing components. The lustrous beauty of ENDURO harmonizes with any surroundings . . . stays bright and sanitary indefinitely without laborious polishing. Republic makes all analyses of stainless to meet every application. Coupon will bring full information by return mail.

PRODUCTION PROBLEMS VANISH when you specify Republic Steel Sheets. Whatever your requirements, your Republic representative or steel distributor can help you select the ideal type of sheet. He is backed by a broad selection including hot rolled, cold rolled, continuous galvanized, Galvannealed, Electro Paintlok, Electro Zincbond®, Electro Flashcote and other types in a wide variety of analyses.



END PRODUCTION BOTTLENECKS by sending your sheet steel fabricating problems to Republic's Berger Division. You get the benefit of complete contract fabricating facilities, plus a wealth of experience, designed to form high-quality sheet steel into products or components of your own design, *economically*. Investigate this means of cutting tooling costs and plant additions. Mail the coupon for further data, today.

STEEL

and Steel Products

REPUBLIC STEEL CORPORATION
Dept. C-1034A
3150 East 45th Street, Cleveland 27, Ohio

Please send me further information on:
- ☐ Republic Electro Paintlok
- ☐ Republic ENDURO Stainless Steel
- ☐ Berger Division Contract Manufacturing Facilities
- ☐ Republic Sheet Steel (specify) _____

Name _____ Title _____
Company _____
Address _____
City _____ Zone _____ State _____

ONE OF A SERIES OF INFORMATIVE MESSAGES FROM HYATT . . .

Cylindrical Roller Bearing Retainers . . .

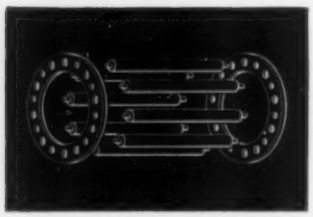
The seven basic types in current use . . . their influence on bearing cost and performance . . . why one type is best suited to your individual design requirements

Most cylindrical roller bearings consist of an inner race, an outer race, a complement of rollers, and a cage or separator which locates and guides the rollers. There are significant differences in the design and construction of these roller retainers. (The word "*retainer*" is used to designate both a cage, which retains the rollers, and a *separator* which only spaces the rollers.) Some retainers are simple and economical, well adapted for volume production, and designed for use where price is a primary consideration. Others are more costly to make but are designed for improved roller guidance, to insure cooler or smoother operation, or to provide longer life in heavy duty service.

Beginning with the most elementary, here are the seven basic types of cylindrical roller bearing retainers in current use, with a brief outline of their construction and characteristics:

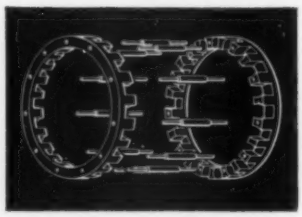
1. TRUNNIONED ROLLER CAGE

The trunnioned roller cage is used for bearings of very thin annulus, where the rollers must be small in diameter, closely spaced, and relatively long. The end rings are economical hardened steel stampings, into which the trunnioned rollers are inserted. The bars which connect the end rings are riveted to the rings at assembly so that the rollers and cage form an integral, non-separable unit. Thus, outer or inner races can be omitted if desired, with rollers operating directly on a suitably hardened shaft or housing bore. This cage is an economical design for volume production and possesses excellent operating characteristics for a wide range of applications.



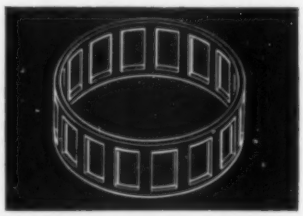
2. POCKETED END RING CAGE

The pocketed end ring cage is restricted to fairly large bore bearings with relatively long rollers. The end rings are bronze. The steel connecting bars are riveted into the end rings and the rollers operate in drilled pockets which guide them accurately. The construction has less tendency to twist or rack, and operates with less end friction because the outside faces of the bronze end rings are smooth uninterrupted surfaces. This type is known as a roller-riding cage, and makes no contact with the bearing races. It can be produced economically in small lots and since it is non-separable, bearing races can be omitted if desired. The characteristics of the pocketed end ring cage make it particularly desirable for applications where long life and heavy-duty service are required.



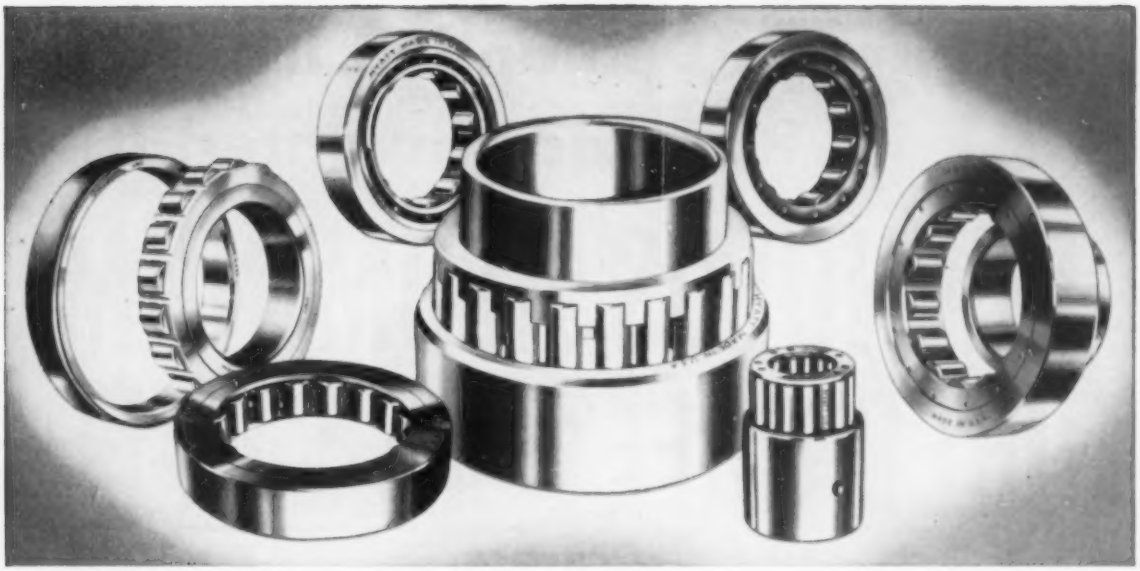
3. STAMPED STEEL SEPARATOR

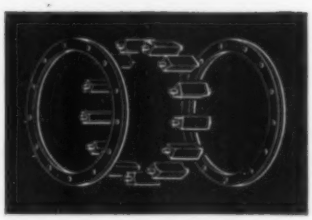
The stamped steel separator does not retain the rollers by itself, but merely separates them. It is a one-piece steel stamping with the separating bars coined to conform to the roller contour, and rides the rollers below their pitch line. Rollers are guided by the race flanges and snap rings, in conjunction with the cage bars. The simple, open design of this separator insures large grease capacity and good lubricant circulation, rendering it relatively insensitive to dirt. Since the separator is retained axially by the roller ends, there is no external requirement for axial location. The stamped steel separator is usable throughout a wide range of bearing sizes where rollers are relatively short (the Hyatt Hy-load series), and is economical for volume production.



4. FORMED BAR CAGE

The formed bar cage is built up of stamped end rings and bars formed to the roller contour. The end rings and bars are riveted together at assembly, making the race and roller assembly a non-separable unit. This cage is used on Hy-load bearings, with double-flanged inner or outer races. This

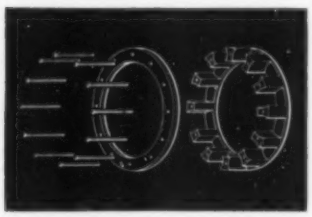




design insures quiet operation, better roller guidance, and provides a smooth contact surface between bars and rollers. This is a roller-riding design requiring no race contact in operation and is well adapted for volume production.

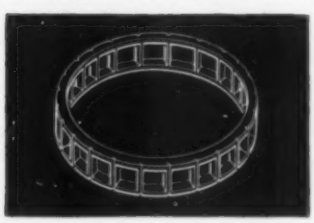
5. DRILLED POCKET CAGE

To construct this type, a bronze cylinder is drilled and reamed to form pockets in which the rollers operate. After the rollers are inserted, a flat end ring is riveted in place so that the rollers are permanently retained in the cage. This design provides extremely close control of the rollers in operation and prevents skewing which would impair both the thrust and radial capacity of the bearing. This is another roller-riding cage comprising a non-separable unit suitable for operation with inner or outer races omitted. The design insures superior performance and is used in applications requiring bearings of better than commercial quality.



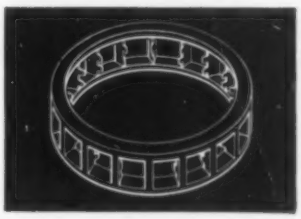
6. SEPARABLE BROACHED POCKET CAGE

This type is used only on the finest-quality bearings where performance is more important than price. It is made of one integral bronze cylinder, with pockets broached for maximum uniformity. This is the preferred type for the finest high-speed precision bearings because it insures minimum friction between rollers and separator, and allows better oil circulation for cooling at high speeds. Moreover, there are no thermal differences in this monolithic construction; the entire unit heats and cools uniformly. The separable feature offers the further advantage of roller removal for inspection of the race operating surfaces.



7. NON-SEPARABLE BROACHED POCKET CAGE

Similar in construction to the above, this design offers all the same inherent operating advantages. It is used in bearings where installation must be "blind," requiring rollers to be retained with the inner or outer race. Controlled roller drop is provided by deforming the connecting bars at assembly after the rollers are in place in the cage. This insures proper retainment but has the disadvantage that the bearing cannot be taken apart for inspection.



HYATT MANUFACTURES ALL SEVEN TYPES of cylindrical roller bearing retainers described above —each the finest of its type. You will find more details in HYATT General Catalog No. 150, or your nearby HYATT Sales engineer will be glad to help you choose the type best suited to your individual design requirements. Remember, HYATT is America's *first* and *foremost* maker of cylindrical roller bearings. Hyatt Bearings Division, General Motors Corporation, Harrison, New Jersey.

GM GENERAL MOTORS

HYATT

ROLLER BEARINGS

Engineers Demanded It!
Reynolds Invented It!

REYNOLDS ALUMINUM TUBED SHEET One-Side-Flat

(Patent Pending)

FLAT SIDE

PATTERN SIDE

The exciting new material to complement your design and engineering skill

Reynolds new Tubed Sheet *One-Side-Flat* is the only sheet with one flat side providing integral tubing in any parallel or non-parallel patterns no matter how complex! Tubed Sheet *One-Side-Flat* (two sheets of aluminum metallurgically bonded together so that the heat transfer passageways are *in the sheet*) is flat on one side and has the built-in tubing pattern on the other side. This amazing material routes gas or liquid wherever needed with greater freedom and greater efficiency and at lower costs.

Like the original Reynolds Tubed Sheet that has its integral tubing pattern expanded on both sides and is widely used in the refrigeration industry, this exclusive new Reynolds development is exciting interest in the refrigeration and other industries because it promises *even more advantages.*

For example, in *refrigerator evaporators,* Tubed Sheet *One-Side-Flat* permits direct contact of the flat side with food packages and ice cube trays thus speeding heat transfer, providing faster freezing. As a *skin for aircraft,* its flat side provides a smooth exterior and the entire sheet can be cooled through the integral tubing offering a possible solution to the "heat barrier" faced by supersonic planes. In *radiant heating panels for buildings,* its flat surface can be finished in a variety of decorative ways and used to face room interiors while hot water is circulating through the integral passageways on the other side of the sheet.

Why not investigate Reynolds Tubed Sheet *One-Side-Flat* for application in your industry? Whether transportation, chemical, petroleum, construction, appliance or other industry, you'll find it an intriguing new material—for amazingly flexible heat transfer use or for other uses your ingenuity may devise. For details contact your nearest Reynolds Office or write direct. *Reynolds Aluminum Fabricating Service, 2051 South Ninth Street, Louisville 1, Kentucky.*

See "Frontier", Reynolds exciting dramatic se[ries]

Write for free 24-page "Catalog of Facilities". Get full details on the tremendous production facilities of Reynolds Aluminum Fabricating Service.

The Finest Products Made with Aluminum are made with REYNOLDS ALUMINUM

REYNOLDS ALUMINUM FABRICATING SERVICE

BLANKING • EMBOSSING • STAMPING • DRAWING • RIVETING • FORMING • IMPACT EXTRUDING • ROLL SHAPING • TUBE BENDING • WELDING • FINISHING

KLIXON PROTECTORS

*Safeguard Dependable Operation of General Radio Variacs**

The new General Radio Company W5MT3 Variac incorporates the latest features in continuously-adjustable autotransformers.

To keep these advanced Variacs operating dependably and give them maximum overload capacity with full safety against overheating, General Radio engineers use KLIXON Manual Reset Protectors. Here's what the Engineering Department says:

"Why KLIXON Protectors?

1. Variacs for bench use need protection from accidental overloads apt to be encountered in laboratory and experimental work.

2. The protector should trip only when the combination of overload and time produces Variac Maximum Temperature limitations. KLIXON Thermal Protectors have time-current characteristics that fit Variacs well.

3. The protector should up-rate Variac for cool operation and derate it for high ambient. KLIXON Thermal Protector does this.

4. The protector had to be as compact and inexpensive as possible in interest of space and dollar economy."

Protect your equipment such as transformers, motors, solenoids and automatic reel cords with KLIXON Protectors. They will prevent production delays, and save on costly repairs and replacements.

*General Radio Company Trademark

KLIXON®

METALS & CONTROLS CORPORATION
SPENCER THERMOSTAT DIVISION
907 FOREST STREET, ATTLEBORO, MASS.

Two Metals are often Better Than One

...and General Plate CONFLEX*

is a case in point

General Plate Composite Metals, made by joining two dissimilar metals together with an inseparable bond, offer many advantages not always possible in a single metal.

Consider CONFLEX — a General Plate Composite Metal of hardenable steel faced on one or both sides with sheet copper. CONFLEX is a superior spring material, yet it offers better electrical conductivity and greater strength — at lower cost — than comparable copper alloys.

It can be easily formed before hardening — then heat treated to the desired spring characteristic with greater uniformity. In mechanical springs, such as pen and pencil clips, the copper surface is excellent for electroplated finishes.

CONFLEX is available in long length coils slit to desired widths for automatic machine feeding. All in all it offers many advantages in the manufacture of electrical and mechanical spring parts.

Why not get acquainted with CONFLEX by sending for a free sample today?

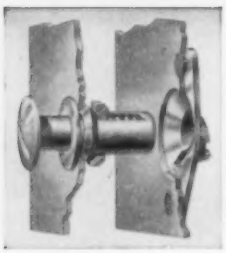
If you are looking for stronger or lighter metal components, with better electrical and mechanical properties and fewer corrosion problems, or if you are interested in conserving critical metals or reducing parts costs, you should be investigating General Plate Composite Metals. Catalog PR-700 covering precious to base and base to base cladments, TRUFLEX® Thermostat Metals, composite electrical contacts, buttons and rivets, etc. sent free. Write for it!

*Trade Mark of Metals & Controls Corporation

You can profit by using General Plate Composite Metals!

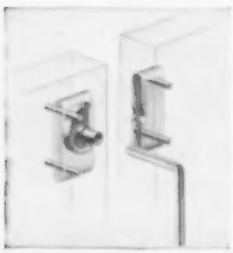
METALS & CONTROLS CORPORATION
GENERAL PLATE DIVISION
17 FOREST STREET, ATTLEBORO, MASSACHUSETTS

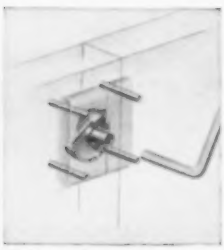
3 ways to save on assembly costs



QUICK-LOCK For fastening removable access doors and panels. Because of its ease of installation, QUICK-LOCK is ideal for assembling removable panels. A 90° turn locks it in place. Stud is self-ejecting when unlocked; visual inspection shows whether fastener is locked. Spring loading takes initial load; solid supports carry increased load. Available in a wide range of sizes.

SPRING-LOCK One-piece fastener for blind holes has load-carrying steel spring wire. Spring steel arms lock fastener securely, prevent loosening under vibration. SPRING-LOCK will work with varying panel thicknesses, locks with a twist of the wrist. Made in all-metal and plastic with steel insert. The molded design permits heads to be made in various shapes for refrigerator shelf supports, washer knobs, brackets. Available in a wide variety of shapes and sizes, and also in custom designs.





ROTO-LOCK Serrated, tapered cam is engaged by formed lug as fastener is locked. Cam action draws panels together tightly, insures locking even under conditions of misalignment. Opens easily for demounting. ROTO-LOCK carries heavy tension and shear loads; can be used for air and water-tight seals: recesses completely into panels. Solidly built without springs or delicate mechanical parts, unaffected by arctic temperatures or field service.

Simmons

QUICK-LOCK
SPRING-LOCK
ROTO-LOCK
LINK-LOCK
DUAL-LOCK

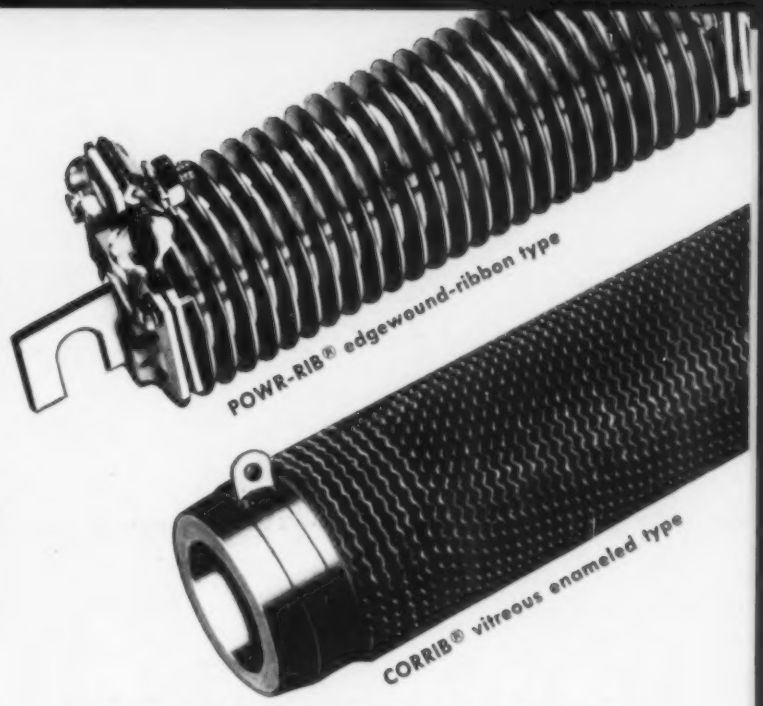
JUST OUT!
NEW 36-PAGE CATALOG WITH APPLICATIONS
SEND FOR IT!

Simmons Fasteners are widely used in refrigerators, washing machines, electrical equipment, electronic assemblies, prefabricated portable shelters, coolers, demountable furniture. Every Simmons Fastener is a service-proved design with a long record of assembly-cost saving in many industries.

If you are interested in cutting your costs, turn to Simmons Fasteners—the fasteners with *uses unlimited*. Write for samples and catalogs today.

SIMMONS FASTENER CORPORATION
1751 NORTH BROADWAY, ALBANY 1, NEW YORK

specify OHMITE® *Power Type* **RESISTORS** for high current low resistance applications—



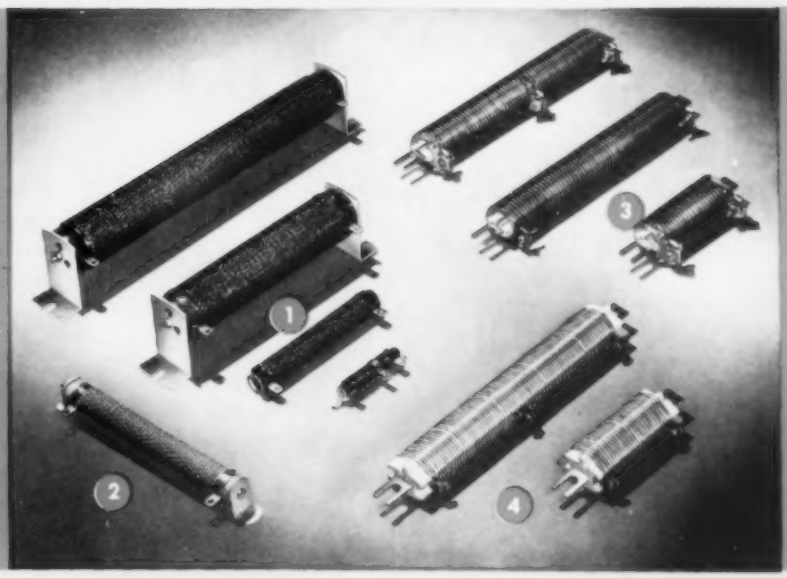
The Ohmite line of specialized CORRIB and POWR-RIB resistors solves your high-current, low-resistance problems. The four basic types of Ohmite units (shown below) handle a wide range of special power resistor needs. They are designed for continuous or intermittent duty and provide dependability for heavy-duty applications. Available in Fixed or Adjustable "DIVIDOHM®" Types.

IN STOCK—22 Corrib Resistance Values in 300 Watt Size (Core 8½" x 1⅛").

IN STOCK—26 Powr-Rib Resistance Values in 5 Section Size (17⅞" long).

Write for Bulletin 144

1. **CORRIB® vitreous-enameled corrugated-ribbon type**
   Fixed, tapped, and adjustable types in 25 sizes, 90 to 1500 watts. Resistances from .04 to 110 ohms.
2. **CORRIB® bare threaded tube type**
   For continuous or intermittent operation at higher than normal 375°C temperature rise. In two sizes, from 0.36 to 4.25 ohms.
3. **POWR-RIB® edgewound-ribbon type**
   Has ceramic core, sectionalized to resist shock. Four sizes. Values .043 to 1.6 ohms; 24 to 95 amps.
4. **POWR-RIB® round-wire type**
   Has sectionalized core similar to ribbon type. Four sizes. Values from .69 to 25 ohms; 5.1 to 18.4 amps.



Be Right with OHMITE®

RHEOSTATS
RESISTORS
RELAYS
TAP SWITCHES
TANTALUM CAPACITORS

OHMITE MANUFACTURING COMPANY, 3611 Howard Street, Skokie, Illinois (Suburb of Chicago)

6 good reasons why industry prefers

OHMITE®

HIGH CURRENT

ROTARY

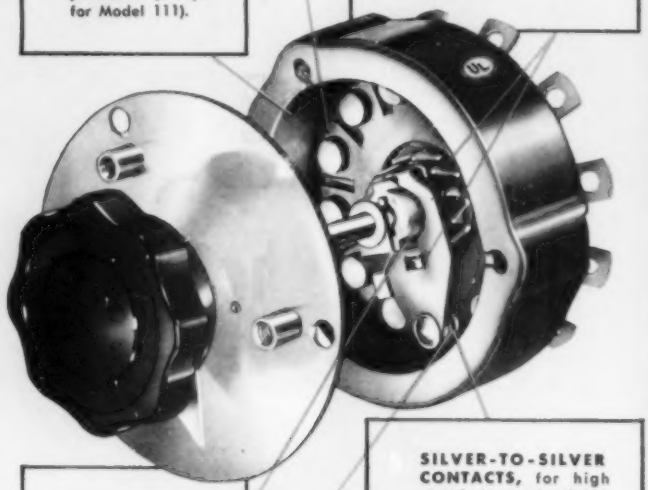
TAP SWITCHES

Check the features at right that make Ohmite tap switches preferred by industry everywhere. Shown below are five sizes of high-amperage, multi-point selectors. They are extremely compact, providing up to 12 tap terminals. In addition to the types and sizes shown, Ohmite tap switches are supplied in open, all-ceramic, shorting and non-shorting types. All Ohmite tap switches can be mounted in tandem for multiple-pole operation.

EXTREMELY COMPACT, yet have many high-current taps, perfectly insulated. Terminals are convenient for wiring. Back-of-panel mounting.

CERAMIC CONSTRUCTION provides perfect insulation unaffected by arcing. Contacts and mechanism are entirely enclosed and protected (except for Model 111).

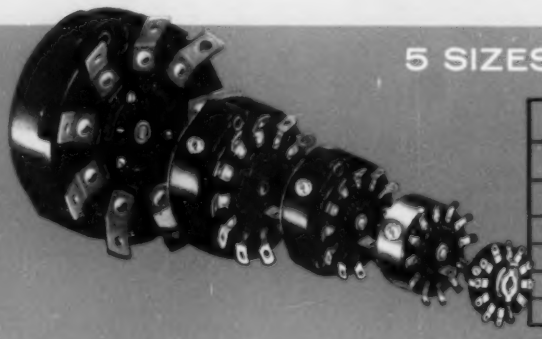
"SLOW-BREAK" MECHANISM, incorporating a positive cam-and-roller, provides "slow-break, quick-make" action, particularly suited to alternating current. Minimizes sparking, extends contact life.



SILVER-TO-SILVER CONTACTS, for high electrical conductivity. Have low surface resistance, and eliminate contact maintenance.

"DEAD" SWITCH SHAFT. Completely insulated from the load by a high-strength driving hub which will withstand a 2000-volt test.

SELF-CLEANING ROTOR CONTACT. Slightly rounded, assures perfect seating and producing slight rubbing motion with every operation.



5 SIZES: 10, 15, 25, 50, and 100 AMPS

AC RATINGS		
AMP	VOLTS	NO. TAPS
10	150	2 to 11
15	150	2 to 12
25	300*	2 to 12
50	300*	2 to 12
100	300	2 to 8

*150 Volts between taps.

Write on company letterhead for Ohmite Catalog and Engineering Manual No. 40.

OHMITE MANUFACTURING CO.
3611 Howard St., Skokie, Illinois
(Suburb of Chicago)

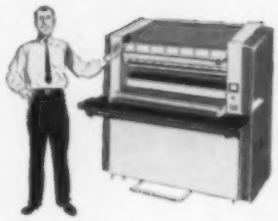
Be Right with **OHMITE®**

RHEOSTATS • RESISTORS • RELAYS • TAP SWITCHES
TANTALUM CAPACITORS

You Need It!

The boom in production means more pressure than ever for engineering prints. A new, modern reproduction unit with higher speeds, more operator conveniences will help you deliver them.

You Want It!



Take this opportunity to replace that old, inadequate reproduction machine with the efficient new unit you've been wanting—a faster, better engineered, and trouble-free *modern* machine!

You'll Surely Get Management Approval!

If your firm, like most, is gearing up for greater-than-ever production, you couldn't pick a better time to get the approval of management for new, modern, higher-production equipment.

NOW Is the Time to Get Your New, Modern Bruning Copyflex Machine!

To meet production's push for more engineering prints, you couldn't pick a better time to get a new, modern reproduction machine. And you couldn't make a wiser choice than efficient, trouble-free Copyflex!

In just the last year, Bruning has introduced five new, advanced machine models, one of which is shown at the right. These machines offer you the famous problem-free installation and operation of Copyflex . . . no exhaust venting, no plumbing or auxiliary equipment, no installation other than an electrical connection. They bring you faster reproduction speed and a host of operator conveniences such as fast return of originals, automatic separation, front or rear delivery. They are efficient, economical, modern reproduction machines that will help you boost your drafting room output, keep costs at a minimum.

Now is the time to act. Mail the coupon below. You'll be glad you did!

COPYFLEX MODEL 500—A new, ultra-fast, heavy volume machine offering top mechanical speed of 40 f.p.m., automatic separation, front or rear delivery, automatic stacking, and a host of other advanced features.

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Best Process! Best Machines! Best Selection of Materials!

Specialists in Copying Since 1897

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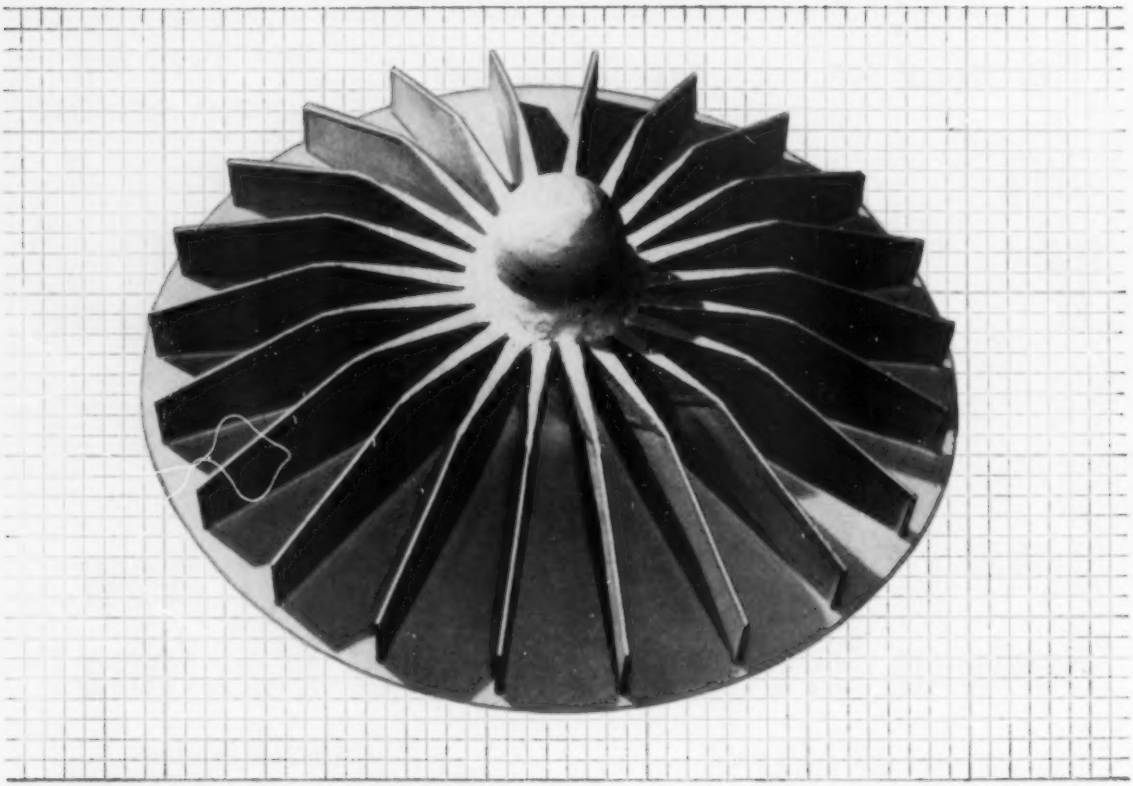
Please send me information on Copyflex process and Model 500 Machine.

NAME_____ TITLE_____

COMPANY_____

ADDRESS_____

CITY_____ COUNTY_____ STATE_____



22-inch Diameter Wheels Investment Cast . . . at a 50% Saving

Turbine wheels, 22 inches in diameter and weighing close to 100 pounds, are now being mass-produced by HAYNES' precision-investment-casting process. The wheels are made of stainless steel and are used in the turbocharger section of a compressor. At one time a lengthy profile machining operation was needed to shape the intricate blades. Investment-casting eliminated this operation and cut production costs in half.

The savings realized on this wheel are typical of the many economies made possible by HAYNES' precision-investment-casting process. This modern mass-production method eliminates many machining, grinding, and assembling operations. Intricate contours, odd-shaped cavities, and thin edges can all be cast to size. Two or more parts can be designed and produced as one integral part. In most instances, an investment-cast part can be placed in operation as soon as it is delivered.

For information on how you can use HAYNES' investment-casting process to keep production costs down, write to any of the District Sales Offices listed below.

HAYNES TRADE-MARK ALLOYS

HAYNES STELLITE COMPANY

A Division of Union Carbide and Carbon Corporation

UCC

General Offices and Works: Kokomo, Indiana

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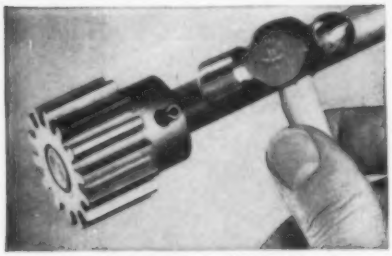
Chicago • Cleveland • Detroit • Houston • Los Angeles • New York • San Francisco • Tulsa

"Haynes" is a registered trade-mark of Union Carbide and Carbon Corporation.

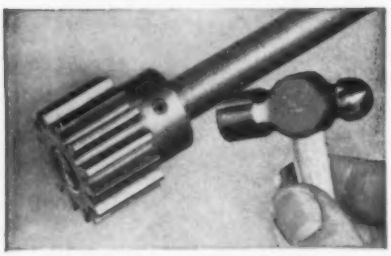
Where can you use this simple fastener?

No threading, peening or precision drilling with ROLLPIN

Rollpin is driven into holes drilled to normal production-line tolerances.



It compresses as driven.



Rollpin fits flush . . . is vibration-proof.

Rollpin is the slotted tubular steel pin with chamfered ends that is cutting production and maintenance costs in every class of industry.

This modern fastener drives easily into standard holes, compressing as driven. Its spring action locks it in place—regardless of impact loading, stress reversals or severe vibration. Rollpin is readily removable and can be re-used in the same hole.

* * *

If you use locating dowels, hinge pins, rivets, set screws—or straight, knurled, tapered or cotter type pins—Rollpin can cut your costs. Mail our coupon for design information.

2330 Vauxhall Road, Union, New Jersey
Dept. 216-72, Elastic Stop Nut Corporation of America

Please send me the following free fastening information:

☐ Rollpin bulletin
☐ Elastic Stop Nut bulletin
☐ Here is a drawing of our product. What fastener would you suggest?

Name _____ Title _____
Firm _____
Street _____
City _____ Zone _____ State _____

MUELLER BRASS CO. improves LENSOMETER lower cost

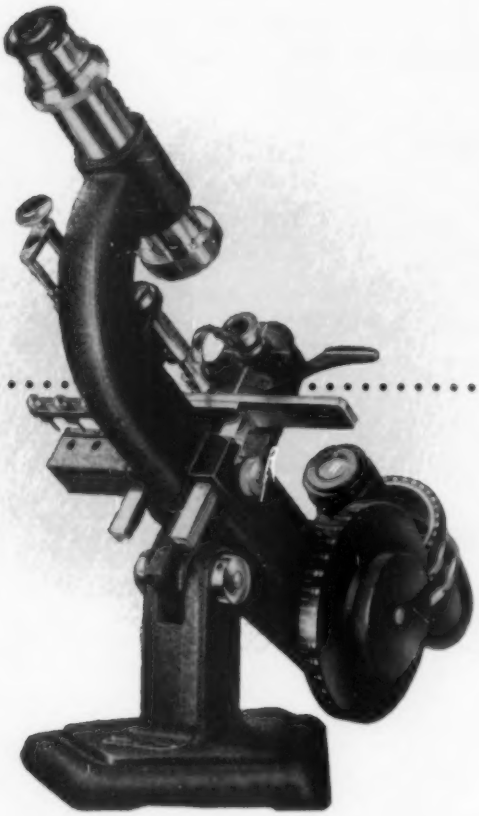
FORGED PART APPROXIMATELY ½ SIZE

Precision and extreme accuracy are vitally important functions of the Lensometer, manufactured by the Instrument Division of the American Optical Company, Buffalo, N. Y. The Lensometer is used to determine the focal strength and axis of an optical lens and, consequently, must be extremely precise in operation to provide accuracy and uniformity in lens prescriptions.

Forgings made by the Mueller Brass Co. play an important role in the construction of the Lensometer and contribute to its outstanding performance. Formerly, the body of the Lensometer was produced from *three* sand castings, but these now have been replaced by just *two* forgings. Naturally, this simplifies assembly, and the big forged bronze main support arm, shown above, along with the lens support bracket insures the constantly accurate alignment of the instrument. During the first year when forgings were used instead of castings, American Optical not only recovered the initial tooling costs but also realized considerable savings on each Lensometer produced. This is another good example of the way Mueller Brass Co. forgings can benefit a product two ways . . . better performance and lower costs. Chances are, your product can likewise be improved at a savings to you if you specify brass, bronze or aluminum forgings made by the Mueller Brass Co.

FORGING

at substantially



• WRITE TODAY FOR THE ENGINEERING MANUAL YOU NEED

Mueller Brass Co. Forgings Engineering Manual H-58565 ☐

Tuf-Stuf Aluminum Bronze Alloys Engineering Manual H-58563 ☐

600 Series Bearing Alloys Engineering Manual FM-3000 ☐

Copper Base Alloys in Rod Form Engineering Manual FM-3010 ☐

METALS AND ALLOYS REVIEW

by FRANK M. LEVY

Vice-President and Director of Research

One of our most interesting series of alloys is the group which we market under the tradename "Tuf-Stuf" . . . a group of aluminum bronze alloys with range and flexibility to meet the most demanding needs. They are high copper base alloys containing from 9% to 13% aluminum and varying amounts of iron, nickel and manganese. Being free of zinc, they are not subject to dezincification. Tuf-Stuf alloys have a low coefficient of friction, good wearing qualities, high tensile strength, high hardness and the ability to withstand heavy pounding. Some of the alloys can be hardened by heat treatment. In the harder grades, these alloys are used for heavy duty service where high compressive loads are encountered and where lubrication may be scant. Present day increases in operating speed of modern machine equipment and the economy of little or no machine "down" time has made Tuf-Stuf popular in the machine tool industry. It is used in a multitude of applications where resistance to wear is important, such as: Drill Jigs, Feed Nuts, Rollers, Cams, Collets, Gibs, Gears, Boring Bar Guides, Lead Screw Nuts and Clutch Shifter Forks. Also, because of their ability to withstand higher stresses and resist season-cracking, these alloys are ideally suited for threaded nuts and bolts and pole-line hardware.

The unusual physical properties of the Tuf-Stuf series have made it particularly useful in the chemical and allied industries. These alloys combine the strength and ductility of medium steel with high resistance to corrosion by many chemicals. Tuf-Stuf alloys will not only resist oxidation at elevated temperatures, but will also retain a greater portion of their strength and hardness at these temperatures than will the copper zinc alloys. These properties make them ideal in the aircraft industry for valve seat inserts, spark plug bushings, valve guides and propeller hub cones.

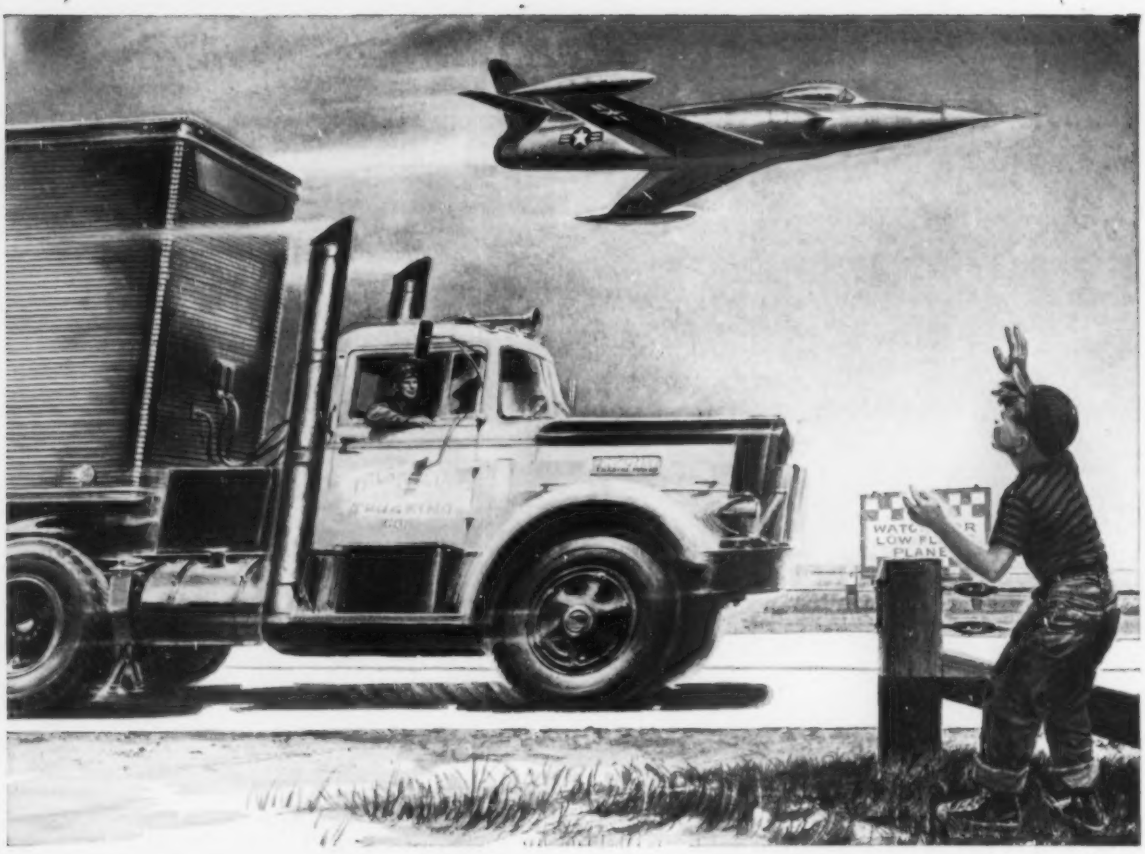
Tuf-Stuf alloys are supplied as forgings, rod or screw machine products. As forgings the grain structure can be controlled to produce parts that are strongest at points of greatest stress and strain. Relatively intricate shapes can be forged to closer tolerances than sand castings. Where appearance is a factor, a forging may easily prove more economical since a minimum amount of machining, buffing or polishing is required before finishing.

If you'd like more information about this series of alloys, drop me a line or better yet, send me your sample part or blueprint and an explanation of its use and we'll be glad to submit our recommendations.

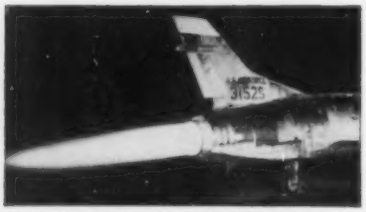
MUELLER BRASS CO.

PORT HURON 17, MICHIGAN

178



Jets on the highway...how soon?



When heat's on. Few metals match Inconel nickel-chromium alloy in its resistance to high temperatures. In a jet plane flame tube, Inconel retains stability despite white heat.

Home front duty. Inconel is widely used in the control mechanisms of pop-up toasters and other familiar home appliances. Operating temperatures reach 600°F., so working parts including main switch, relay and springs are made of *Inconel*.

Perhaps sooner than you think!

Automotive engineers predict the day is not far off when you'll be seeing on the road . . .

Trucks . . . passenger cars . . . buses . . . all powered by gas turbine engines. Engines similar to those in jet aircraft!

It's an exciting prospect. But not yet a reality, for certain technical problems must still be ironed out. One of them involves the search for economical, heat-resisting alloys. They must be strong and tough . . . able to stand red heat . . . and not go to pieces at sudden changes in temperature.

The designers of aircraft engines found answers to *their* problems in such Inco-developed products as Inconel* nickel-chromium alloy, the Nimonic* group of nickel-chromium alloys, and other nickel alloys which we developed especially for aircraft use.

We're working to help the automotive engineers now. *And when gas turbine autos and trucks hit the road commercially, you can be sure nickel alloys will have made it possible!*

If you have a problem in which corrosion, high or low temperatures, stresses or fatigue are troublesome factors, let's talk it over. One of the more than fifty Inco Nickel Alloys now available may have just the combination of properties you want. Write us. The International Nickel Company, Inc., 67 Wall St., New York 5, N. Y.

INCO TRADE MARK

INTERNATIONAL NICKEL

Nickel Alloys Perform Better, Longer

*Inconel and Nimonic are registered trademarks of The International Nickel Company, Inc. applied to nickel-chromium alloys produced and marketed by it.

ALLIS-CHALMERS

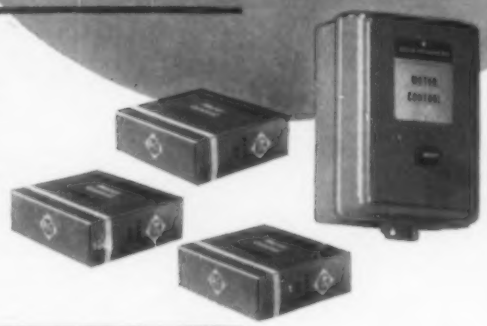
MOTOR CONTROL

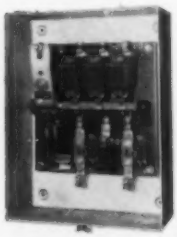
a Complete Line

SIZE 0-3 STARTERS

Converta-Kits Permit Easy Modification of Basic Starter

You get MORE . . . more flexibility with Allis-Chalmers control. A screwdriver and the proper *Converta-Kit* are all you need to change a basic Allis-Chalmers size 0-3 starter into the exact unit demanded by your production. *Converta-Kits* are available for push-button, selector switch and electrical interlock modifications. Starter replacement parts—contacts, magnetic coils and overload relays —are also available in packaged kits.





1. Arc across contacts as they start to open.
2. Strong blowout action forces arc to center.
3. Contacts fully open — arc extinguished.

NEW LINE OF SIZE 4-5-6 STARTERS

Quick Quenching Extends Contact and Chute Life

Heart of these starters is a new contactor which uses a revolutionary principle of arc interruption. In centering the arc, increased blowout action and fast quenching result from a combination of thermal convection and magnetic action. Since the arcing time is sharply curtailed, contact and chute life are greatly extended.

HIGH VOLTAGE STARTERS

Complete "Line-to-Load" Control and Protection

Allis-Chalmers Type H starters are built in a wide range of ratings for squirrel-cage, wound-rotor and synchronous motors . . . for full or reduced voltage — reversing or non-reversing — with plugging, dynamic braking and multi-speed features. Built into the starter is the type and degree of protection dictated by the application.

What is your control problem?

As manufacturers of a diversified line of industrial equipment, Allis-Chalmers has solved thousands of control application problems. This specialized experience is yours when you specify Allis-Chalmers control. See your Allis-Chalmers representative or write Allis-Chalmers, General Products Division, Milwaukee 1, Wisconsin.

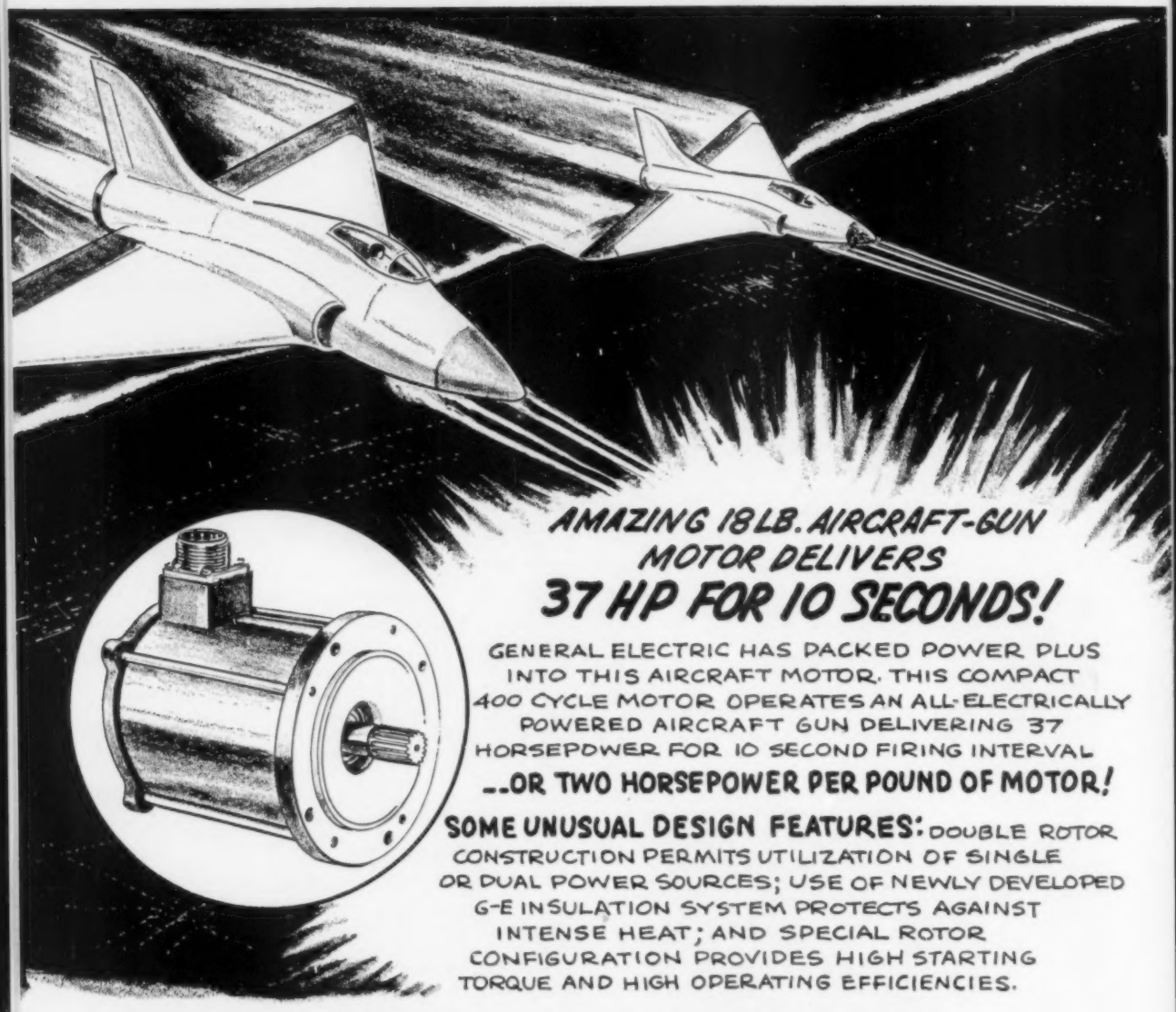
Converta-Kit is an Allis-Chalmers trademark.

A-C ALLIS-CHALMERS

A-4988

ALLIS-CHALMERS

DESIGN SOLUTIONS with G-E



AMAZING 18 LB. AIRCRAFT-GUN MOTOR DELIVERS 37 HP FOR 10 SECONDS!

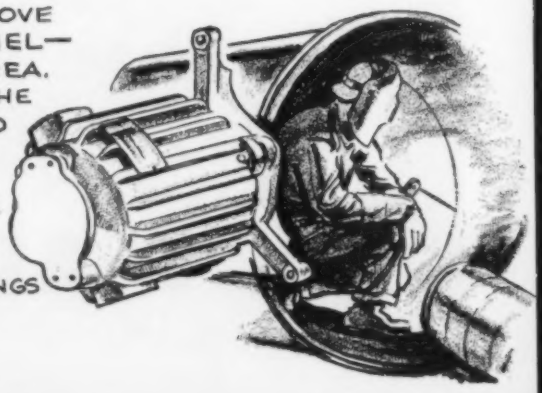
GENERAL ELECTRIC HAS PACKED POWER PLUS INTO THIS AIRCRAFT MOTOR. THIS COMPACT 400 CYCLE MOTOR OPERATES AN ALL-ELECTRICALLY POWERED AIRCRAFT GUN DELIVERING 37 HORSEPOWER FOR 10 SECOND FIRING INTERVAL

...OR TWO HORSEPOWER PER POUND OF MOTOR!

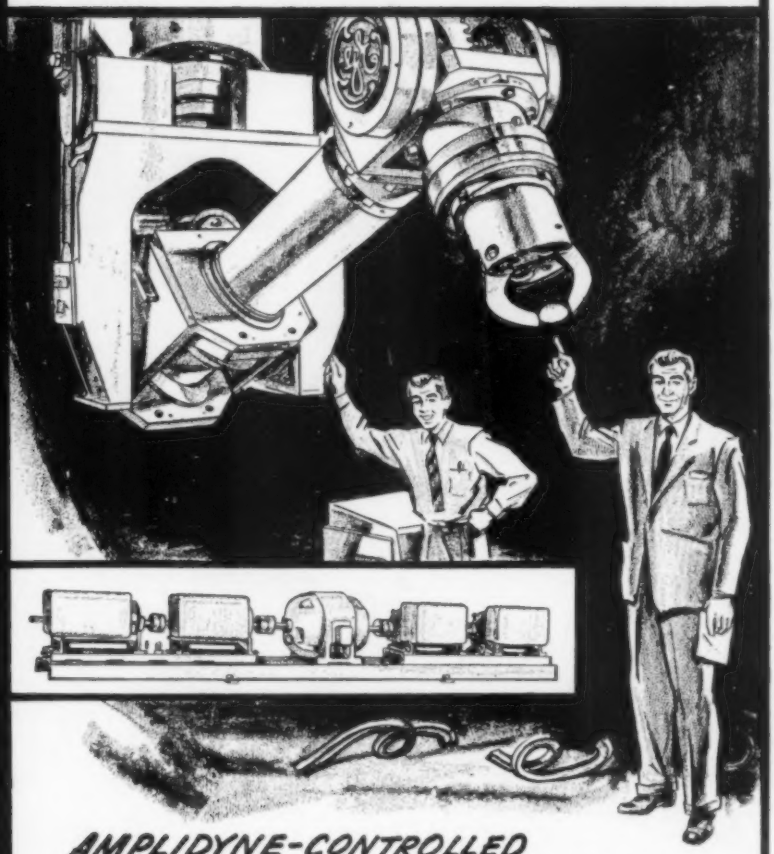
SOME UNUSUAL DESIGN FEATURES: DOUBLE ROTOR CONSTRUCTION PERMITS UTILIZATION OF SINGLE OR DUAL POWER SOURCES; USE OF NEWLY DEVELOPED G-E INSULATION SYSTEM PROTECTS AGAINST INTENSE HEAT; AND SPECIAL ROTOR CONFIGURATION PROVIDES HIGH STARTING TORQUE AND HIGH OPERATING EFFICIENCIES.

THIS SPECIALLY COOLED G-E MOTOR OPERATES WHERE DEPENDABILITY CAN MEAN LIFE ITSELF!

THIS G-E MOTOR DRIVES A VENTILATOR TO EXHAUST WELDING FUMES WHICH CAN PROVE DEADLY IN THIS UNDERGROUND CABLE TUNNEL—OR IN A SHIP'S HOLD OR ANY ENCLOSED AREA. DEPENDABILITY IS IMPERATIVE. DESIGN OF THE TOTALLY-ENCLOSED MOTOR (TO BE MOUNTED INSIDE BLOWER) POSED THE PROBLEM OF DISSIPATING MOTOR HEAT. G-E ENGINEERS SOLVED THE PROBLEM BY BUILDING THE MOTOR WITH SPECIAL HEAT-DISSIPATING RIBS. AN INTERNAL FAN TRANSFERS HEAT FROM THE WINDINGS WHILE THE BLOWER ITSELF BRINGS COOLING AIR OVER THE RIBBED HOUSING.



specialty motors



AMPLIDYNE-CONTROLLED MECHANICAL ARM HAS FINGERS THAT TWIST STEEL OR HANDLE AN EGG

A G-E MULTIPLE AMPLIDYNE SET CONTROLS THE MUSCLES OF O'MAN, AN OVERHEAD MANIPULATOR BUILT BY GENERAL ELECTRIC. O'MAN CAN KNOT STEEL BARS, YET DEMONSTRATES A DELICATE TOUCH WHEN IT LIFTS AN EGG WITHOUT BREAKING IT. O'MAN IS THE WORLD'S LARGEST MECHANICAL ARM BUILT TO SUBSTITUTE FOR HUMAN BRAWN IN RADIO-ACTIVE AREAS.

A SYSTEM CONSISTING OF G-E DEVELOPED AMPLIDYNES PROVIDES 20 TO 1 SPEED CONTROL, DYNAMIC BRAKING, CURRENT LIMIT OVERLOAD PROTECTION, AND ADEQUATE AMPLIFICATION TO KEEP CONTROLLER SMALL.

AVAILABLE: COMPLETE SMALL MOTOR ENGINEERING ASSISTANCE FOR YOU!

HERE'S THE SPECIAL ATTENTION YOUR SMALL MOTOR PROBLEMS GET AT G-E.

1

YOUR LOCAL G-E APPARATUS SALES ENGINEER LEARNS ALL ABOUT YOUR MOTOR NEEDS.

2

HE CALLS A TEAM OF FACTORY ENGINEERS WITH YEARS OF MOTOR APPLICATION EXPERIENCE.

3

AT THEIR DISPOSAL ARE G.E.'S COMPLETE DEVELOPMENT AND TESTING FACILITIES.

4

IN SHORT ORDER A SAMPLE G-E MOTOR IS READY FOR TESTING ON YOUR PRODUCTS.

FOR THIS COMPLETE HELP, CONTACT YOUR NEARBY G-E APPARATUS SALES OFFICE.

WRITE FOR MORE INFORMATION COVERING G-E EQUIPMENT DESCRIBED IN THIS AD TO GENERAL ELECTRIC CO., SECT. 633-3, SCHENECTADY 5, N.Y.

GENERAL ELECTRIC

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"STOCK ANSWER"
to many a design problem

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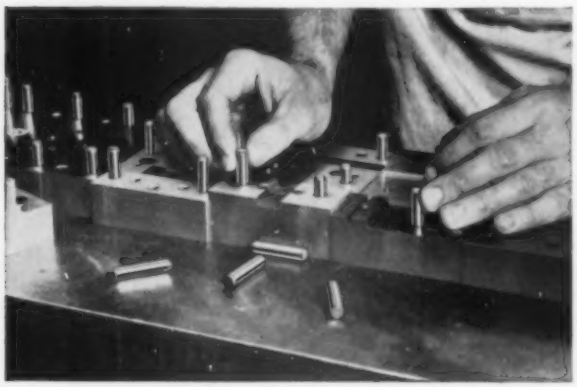
ALLEN DOWEL PINS are being profitably employed in a thousand and one ingenious ways beyond their conventional applications in tool and die work — as economical roller bearings, as axles, precision plugs, hinges and wrist pins to name a few.

If you have an application that will utilize the great strength, accuracy and fine finish of Allen Dowel Pins, you can save substantially on the cost of your product — because you can secure them at favorable prices right from your Allen Distributor's stock.

Check the quick facts at the right and write directly to Allen's Engineering Department for further technical information.



SPECIFICATIONS

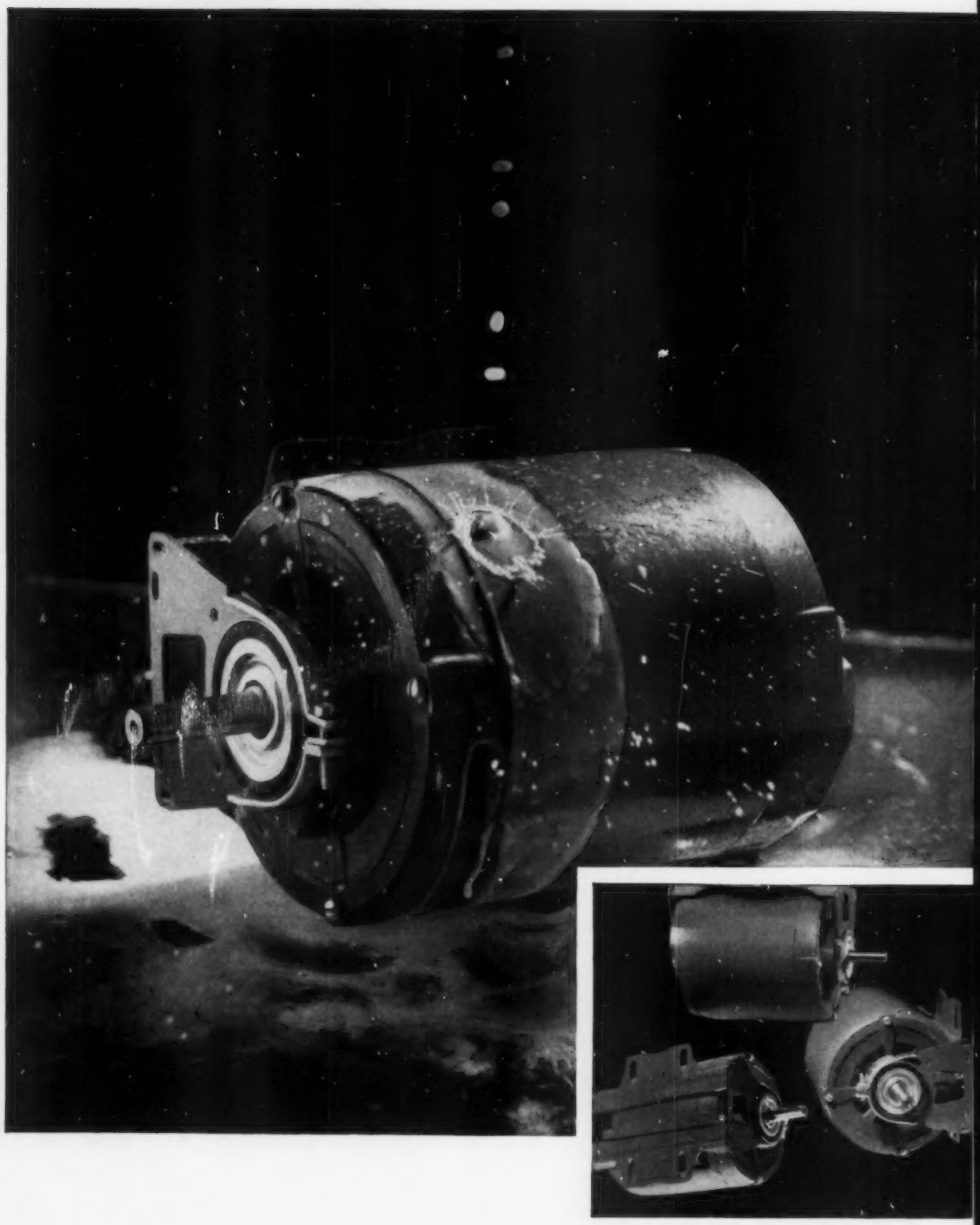
- Made from Allenoy heat treated steel. Surface hardness 62-64, Rockwell C scale; core hardness 52-54. Case depth .010″ to .020″ depending on size.
- Single shear strength 160,000 to 180,000 p.s.i.
- Surfaces precision ground to ± .0001″ with micro-inch finish of 6 RMS max.
- Sizes: Diameters, ⅛″ to 1″. Lengths, ⅜″ to 6″.
- Two standard oversizes — .0002 for press fits between mating parts, or .001 for repair work, or holes machined oversize.

ALLEN HEAD

ALLEN

MANUFACTURING COMPANY

Hartford 2, Connecticut, U.S.A.



Fact 1 . . . no "swiss-cheese" vent holes in the solid frame to restrict mounting angles or allow liquids or dirt to damage windings.

Westinghouse Offers the Only True All-Position Mounting Motor

. . . one important FACT about the new Westinghouse 48-frame fhp motor

A solid, protective frame plus 22% more oil capacity helps make the new Westinghouse 48 frame the only true all-position mounting motor.

By using a straight-through ventilation system—which actually boosts cooling ability—the need for holes in the frame is eliminated. The rigid protection of the solid cover keeps out harmful liquids, dust and dirt, no matter what the mounting angle. Gone, too, are the bothersome whistle noises of other motor designs.

A positive oil-return lubrication system protects the new Westinghouse motor regardless of mounting position . . . your assurance of smooth performance for longer periods, even at peak loads.

Don't expect all these benefits in any other motor.

The Man With The Facts, your Westinghouse sales engineer, has all the information about this new fhp motor line. Contact him today. Or write for DB-2801. It contains complete technical data. Westinghouse Electric Corporation, Small Motor Division, Lima, Ohio.

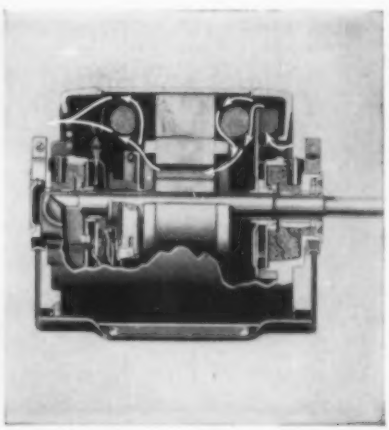
J-03020

YOU CAN BE SURE...IF IT'S

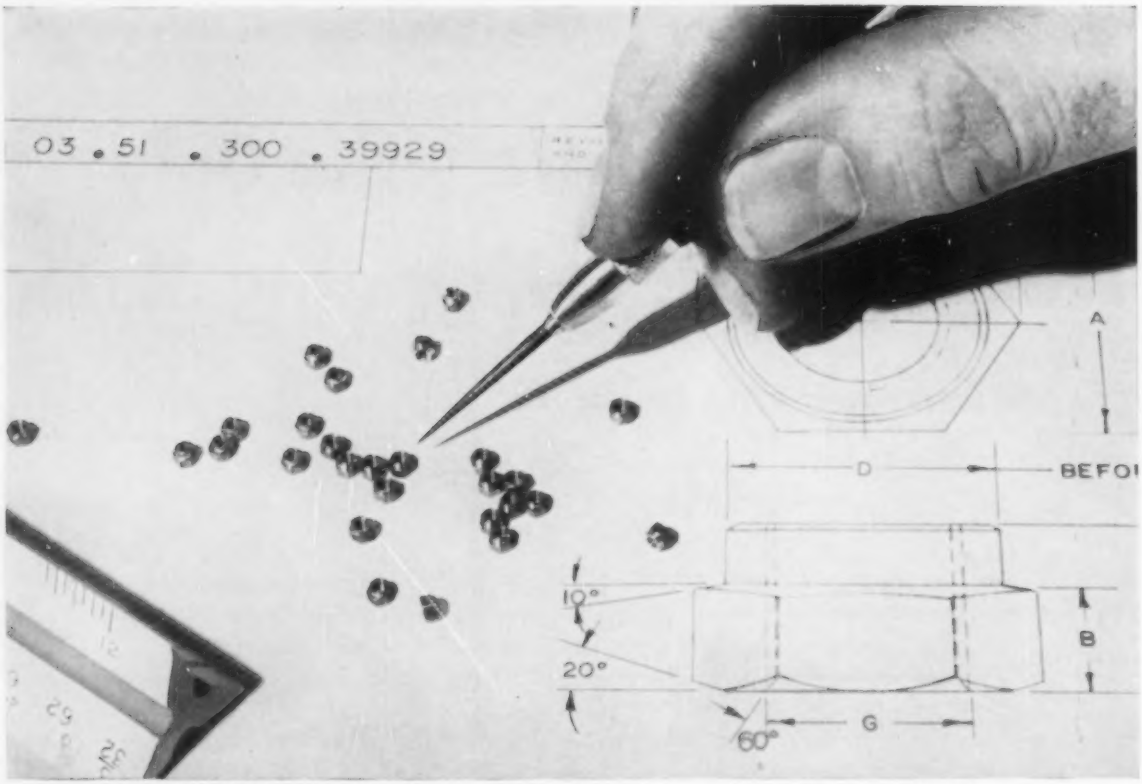
Westinghouse

Fact 2 . . . up to 40% less space needed to stock some sizes. And the motor takes less room in your product, too.

Fact 3 . . . weight savings up to 50%. Conserves mounting and housing space . . . lowers material and shipping costs.



Fact 4 . . . straight-through ventilation assures cooler operation for longer running periods, even at peak loads.



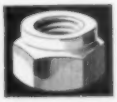
FLEXLOC MICROSIZE locknuts meet designers' needs for tiny precision nuts that retain strength and holding power in the smallest assemblies—servomechanisms, electronic and electrical equipment, all miniature devices.

Design Lighter, More Compact Products with New FLEXLOC Microsize Locknuts

Standard Microsize Locknuts Permit Design Engineers to Develop and Fasten Smaller Assemblies Safely

SIZE	Across Flats		Shoulder Height		Across Corners	Height +.000 −.003
	MAX.	MIN.	MAX.	MIN.	MIN.	
0-80 NF-3B	.111	.107	.047	.042	.123	.075
1-64 NC-3B	.127	.123	.0635	.0585	.141	.090
1-72 NF-3B	.127	.123	.0635	.0585	.141	.090
2-56 NC-3B	.158	.153	.068	.063	.176	.105
2-64 NF-3B	.158	.153	.068	.063	.176	.105
3-48 NC-3B	.190	.183	.071	.066	.210	.120
3-56 NF-3B	.190	.183	.071	.066	.210	.120
4-40 NC-3B	.190	.183	.072	.067	.210	.120
4-48 NF-3B	.190	.183	.072	.067	.210	.120

STANDARD MICROSIZE FLEXLOCs—in sizes ranging from 0-80 to 4-48—are available in brass (either plain or cadmium plated). Consult SPS for miniature nuts of other conventional materials.



New FLEXLOC Microsize locknuts are smaller and lighter than regular FLEXLOCs of the same nominal diameter. Wrenches of smaller size are used to install them. Mating joints or flanges can be designed smaller—with no loss in strength or convenience of assembly.

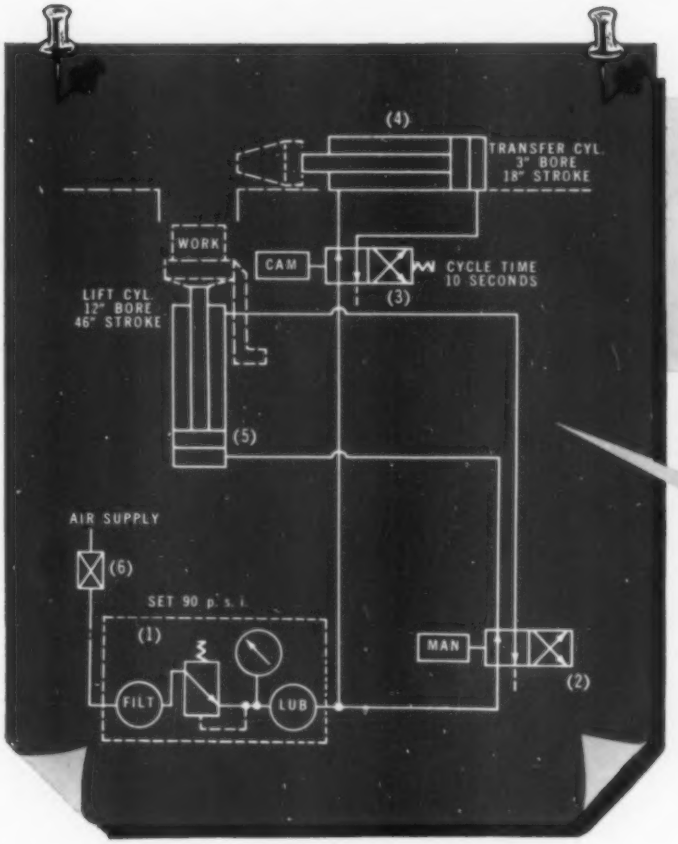
Microsize FLEXLOCs have all the advantages of larger FLEXLOCs. One-piece, all-metal construction—nothing to put together, come apart, lose or forget. Use them as lock or stop nuts—they stay put anywhere on a threaded member as soon as the locking threads are fully engaged. Uniform locking torques insure accurate preloading. There are no nonmetallic inserts to pop out or deteriorate. Moisture, dryness, oil, temperatures to 250°F won't affect these Microsize FLEXLOCs. Just screw them on. They lock and stay locked. Vibration won't shake them loose.

For complete information on Microsize FLEXLOCs, consult your authorized SPS distributor. Or write STANDARD PRESSED STEEL CO., Jenkintown 28, Pa.

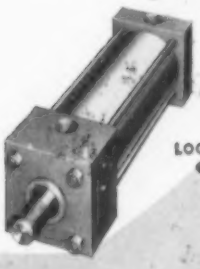
STANDARD PRESSED STEEL CO.

FLEXLOC LOCKNUT DIVISION SPS

JENKINTOWN PENNSYLVANIA



Logan
AIR CIRCUITS



Write for FREE "Circuit Rider" booklet. It explains the above circuit plus many others.

how important is the RIGHT CIRCUIT?

One can't overestimate the importance of a properly designed and equipped circuit. Logan-designed circuits are operating all over the world. Let Logan engineers help you design the circuit to meet your production requirements. For a dependable ONE-SOURCE supplier of air and hydraulic equipment . . . specify Logan.

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- ☐ ABC BOOKLET
- ☐ CIRCUIT RIDER

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US RUBBER **PowerGrip** "Timing®" Belt

"For invention of high order and for particularly meritorious improvements and developments in machines and mechanical processes."

These are The Franklin Institute's words in awarding its 1955 Longstreth Medal to the inventor of U. S. PowerGrip "Timing" Belts—the outstanding contribution to power transmission of the decade.

It's easy to understand why PowerGrip received this great award. By providing near-100% efficiency in positive, non-slip, split-second timing, it has become standard equipment on a wide variety of machines and appliances. The list grows daily.

U. S. PowerGrip Timing Belts—and descriptive literature—are obtainable from factory-trained engineers at any of the 28 strategically located "U. S." District Sales Offices or by contacting us at Rockefeller Center, New York 20, N. Y.

The Franklin Institute, founded in Phila. in 1824, is one of the oldest and most renowned scientific institutions. Its awards are made only after exhaustive studies of contributions to science.

US RUBBER Mechanical Goods Division

United States Rubber

Spring steel within this range...

FOR THE MOST EXACTING NEEDS KNOWN TODAY!

• That this is the age of specialization is certainly true in the use of steels. And in this regard *Athenia Steel* customers benefit especially by two not-too-common factors. First, by extreme control of quality and uniformity, unsurpassed, seldom equalled *anywhere!* Secondly, by painstaking technical service to determine or develop precisely the right steel for any special need.

Here at Athenia we concentrate on cold rolled high carbon flat steels, custom made of .45 carbon and higher, in widths from .015″ to 16″ and thicknesses from .001″ to .065″. Full range of finishes and tempers. We also produce special narrow width stainless, and the new super-tough, corrosion resistant spring material, Nilcor*.

For a new and profitable experience in service and in steel controlled precisely to *your* needs . . . try us!

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Tire Wire, Stainless, Fabricated Braids and Tape

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Round and Shaped Steel Wire, Small Sizes

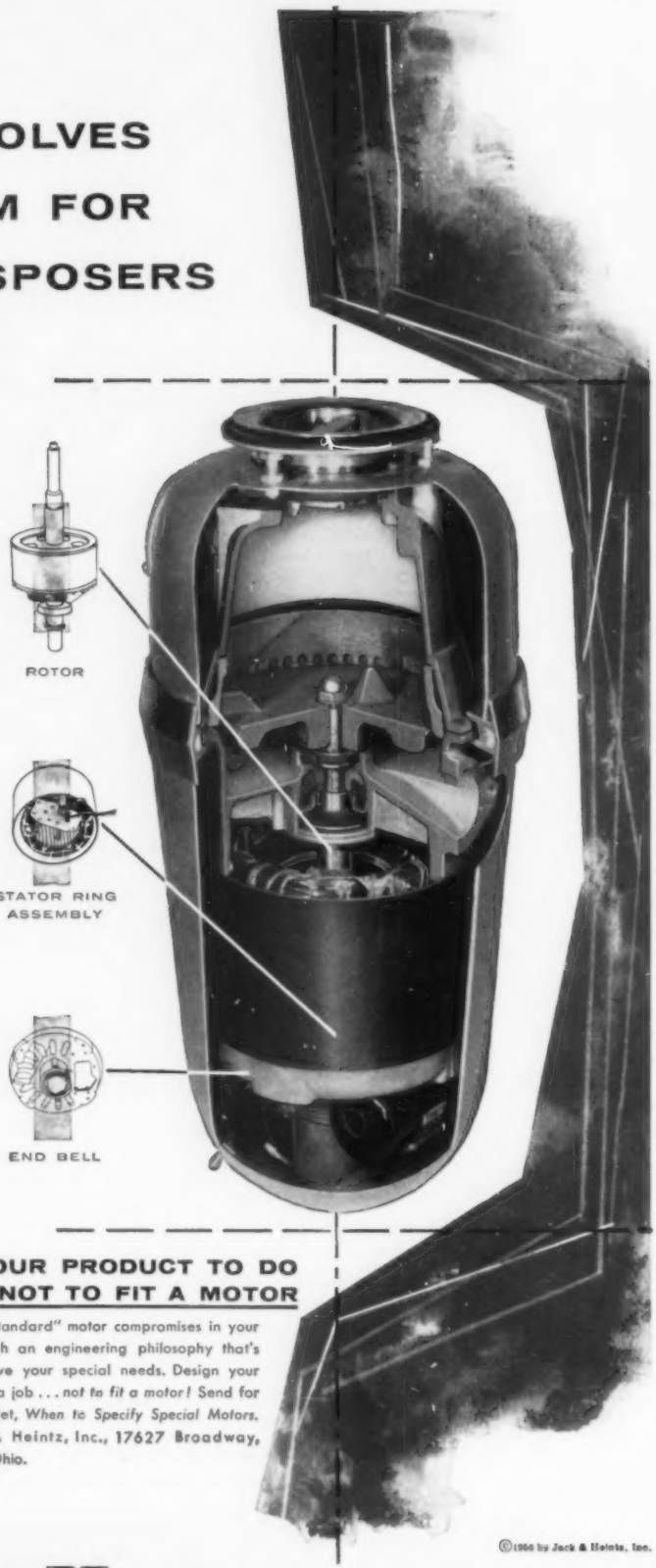
JACK & HEINTZ SOLVES TORQUE PROBLEM FOR ELECTRO-WAY DISPOSERS

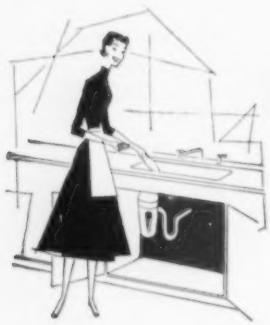
HERE'S THE PROBLEM:

National Rubber Machinery Company of Akron needed a special motor to meet the performance and design requirements of the efficient garbage disposer they manufacture for The Electro-Way Corporation of Los Angeles. The motor had to provide the necessary torque for grinding anything from a potato peeling to a ham bone or artichoke, without stalling. It had to start instantly, even when the disposer was jammed full of waste. Finally, the motor had to give trouble-free service without overheating in the smartly styled, modern housing.

HERE'S THE SOLUTION:

A Jack & Heintz *Customized* Motor provides the answers to all these problems, at a cost that keeps the sales price competitive. A ½-hp, capacitor-start, single-phase motor, with special winding, handles all the varying torque conditions of this kind of service. The end bell is specially designed to provide maximum air openings for ventilation. All electrical components are built for efficient operation under the higher temperatures encountered in this type of service.





DESIGN YOUR PRODUCT TO DO A JOB . . . NOT TO FIT A MOTOR

Avoid those "standard" motor compromises in your product through an engineering philosophy that's geared to solve your special needs. Design your product to do a job . . . *not to fit a motor!* Send for our free booklet, *When to Specify Special Motors.* Write Jack & Heintz, Inc., 17627 Broadway, Cleveland 1, Ohio.

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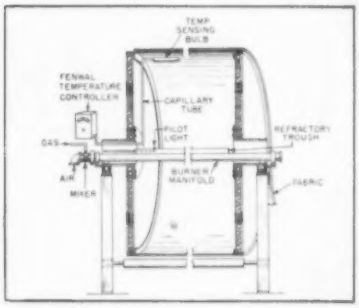
CUSTOMIZED **JACK & HEINTZ** ELECTRIC MOTORS

Controlling A Radiant-Heat Drying Drum

No. 3 in a series — *Showing the Broad Application Range of Fenwal Controls*

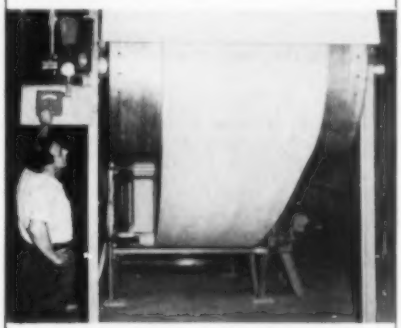
This high-temperature, radiant-heated drying drum is used for drying printed fabrics or for heat-setting synthetic coatings onto fabrics. Particularly interesting is the way in which it combines a Fenwal unit and quick cooling features to secure the close temperature control necessary to prevent scorching the fabric in case of shut-downs.

The drum is usually operated at a surface temperature of 350° to 450°F, but can maintain temperatures up to 700°F, as required. The revolving drum surface is heated by a combination of infra-red rays and convection from a refractory trough heated to incandescence (about 2400°F) by a gas-air manifold burner.



Drum temperature is controlled by a Fenwal Series 540 Indicating Temperature Controller. As shown in the diagram, this is connected by a capillary tube to the temperature-sensing bulb, located close to the interior surface of the drum. The trough and manifold are stationary along the axis of the drum. Flame is played along the surface of the trough by a series of jet nozzles, burning a mixture of air and natural or manufactured gas. To aid in preventing scorching the product, materials used for the drum and heater system are of lowest practical heat capacity. The drum surface is of 16-gauge steel, which assures a low heat content.

Also, the combustion air supply doubles as a coolant for the drum. The air stream is not tied in with the temperature control system and continues to flow after the gas is shut off. Thus, it quickly cools the heater trough and blows the heated air out of the drum. This, plus the low heat capacity of the drum surface, provides the required safeguard against scorching the product during sudden shut-downs.



PRECISE TEMPERATURE CONTROL, provided by a Fenwal Series 540 Temperature Indicating Controller (shown at left) is one of the advantages enabling this huge drying drum to set new records for efficiency. In one installation, three 60" diameter drums of this type are drying the same yardage as 20 previously used steam-dryers.

Control Within ¼ of 1%

When the operator sets this Fenwal Series 540 Controller to the required processing temperature, he knows that temperature will be maintained — on the button! Heat input is controlled by the Fenwal unit, actuating a solenoid valve in the supply line. The gas, maintained at atmospheric pressure by a diaphragm regulator, is drawn into a proportioning mixer valve under negative pressure created by the air stream. The air supply, maintained at approximately one psi, reaches the mixer through a separate supply line.

With the Series 540 Control on guard over the heating system, the manufacturer of this advanced drying equipment states that the temperature of the drum surface is maintained within ± one-quarter per cent of the controller scale — outstanding performance for processing equipment of this type.

A Versatile Instrument

The Series 540 Controller is fully adjustable between 100°F and 700°F. Temperature differential is adjustable between 1% and 4% of scale temperature ranges by internal adjustment of pilot contacts. Uniform sensitivity and close accuracy throughout its range are characteristic, making it an ideal temperature indicating controller for kilns, ovens, liquid baths, baking ovens, packaging machinery and general industrial processing.

For Your Own Applications

Investigate the many different types of Fenwal temperature control and detection devices. Besides the Series 540 described here, these include standard THERMOSWITCH® units, Midgets, Miniatures, etc. Send the coupon for new Catalog No. 500. Remember that Fenwal's engineering staff is always ready to help you solve any temperature control problem.

FENWAL INCORPORATED
27 Pleasant Street
Ashland, Mass.

Please send me your Catalog No. 500. Our specific problem is: .....

.....

.....

Name ..... *Title* .....

Address .....

City ..... *Zone* .. *State* .....

Fenwal CONTROLS TEMPERATURES . . . *PRECISELY*

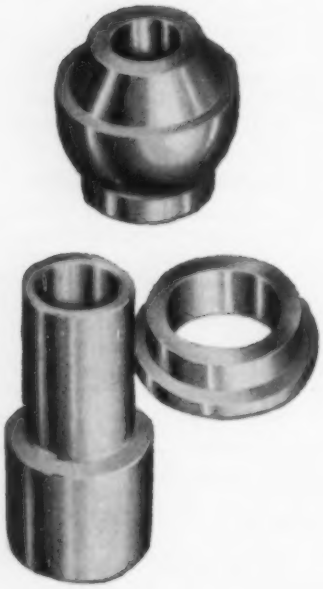
what are your bearing requirements?

A different demand . . . or set of demands . . . is made of bearings in every different product. Chief considerations may be: minimum noise level . . . corrosion resistance . . . low unit cost . . . wear resistance to oscillating or sliding motion . . . operation in presence of moisture . . . or others. When considering a sintered metal bearing for your product, it is essential that you obtain the correct alloy. The wide range of GRAMIX alloys, together with the long experience of our engineering staff in working with bearing applications, assures you of getting the best possible bearing for your product.

THERE IS A GRAMIX®

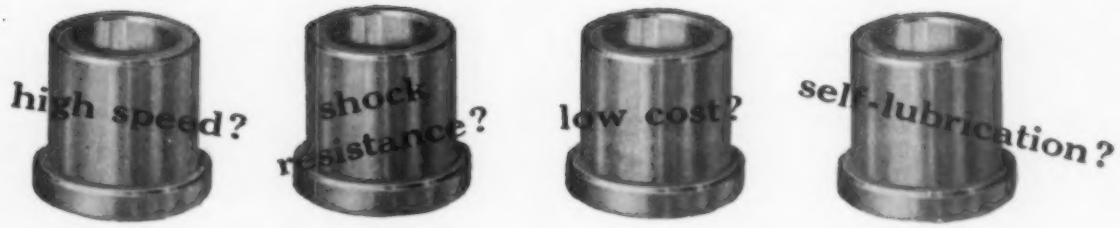
(A PRODUCT OF POWDER METALLURGY)

FOR YOUR

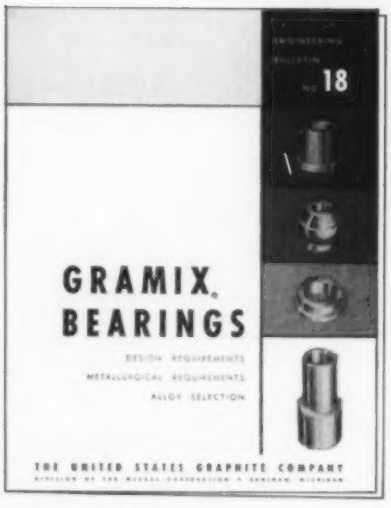


Certainly, there is such a thing as a "general purpose" sintered bearing alloy . . . GRAMIX Grade 81 fills this role, and does it well. But there are also applications that demand special alloys, designed to do a specific job better. There is a wide range of GRAMIX alloys to meet every individual design consideration. Properties of these alloys vary widely: tensile strengths range from 8,600 psi to 25,000 psi . . . elongations from 1% to 10%! Operating characteristics also vary. For example, under conditions where there is minimum lubrication, GRAMIX Grade 183 (copper, tin, lead, nickel) is recommended. For heavy duty operation in a surplus of oil, GRAMIX Grade 307 (copper, tin, lead, carbon) is preferred. These few facts convey an idea of the wide design range of GRAMIX alloys. There is *one* that exactly fits your product . . .

THE UNITED STATES



BEARING ALLOY DESIGN REQUIREMENTS



ENGINEERING BULLETIN No. 18

A NEW GRAMIX ENGINEERING BULLETIN TO HELP THE PRODUCT DESIGNER IN SPECIFYING SINTERED BEARINGS

Product engineers who specify bearing materials will find Engineering Bulletin No. 18 of great help. It presents in concise form much of the knowledge we have accumulated since 1924, when GRAMIX was first produced. Design requirements, metallurgical considerations, and alloy selection are all discussed. A table of data on GRAMIX alloy composition and physical characteristics such as density, tensile strength, elongation, and radial crushing strength is included. The section devoted to selecting the right GRAMIX alloy to fit greatly differing product requirements is an ideally simplified guide to this complex subject. Write for your copy of Engineering Bulletin No. 18 today.

113

GRAPHITE COMPANY

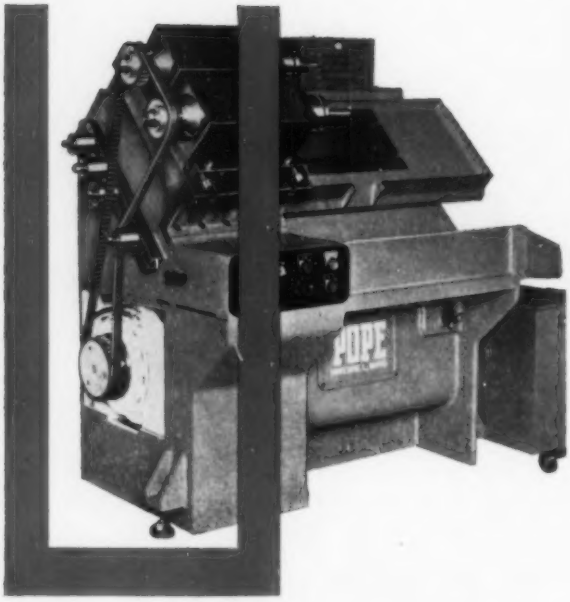
DIVISION OF THE WICKES CORPORATION, SAGINAW, MICHIGAN

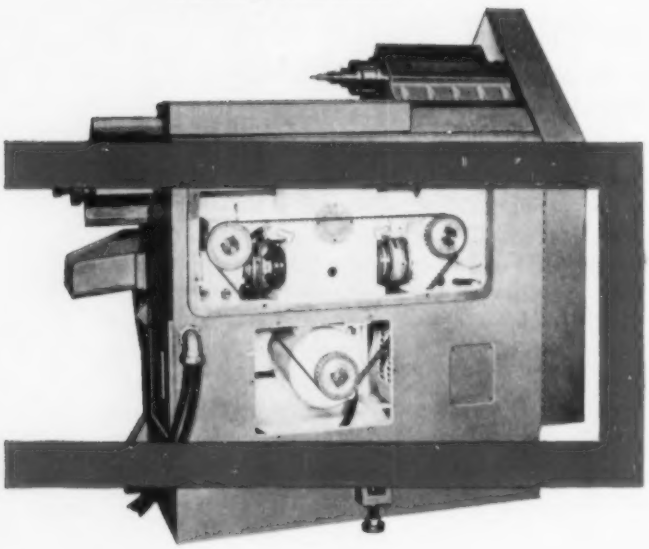
Positive **power transmission with** ***constant angular velocity*** **made possible by**

Gilmer
the original

"Timing®" Belt drive

in New POPE Super-Precision Boring Machine





These photos, taken from Pope's* own literature, show clearly how Gilmer "Timing" Belts are used to drive both spindles and table mechanism of this new precision machine.

The table mechanism, containing neither cams, change gears nor linkages, is under full automatic *electrical* control. A reversible, variable-speed D.C. motor provides infinitely-variable feed and traverse rates, making it as flexible as any hydraulic system. The non-slip "Timing" Belt drive makes it possible to maintain a precise relationship between motor speed and mechanism.

Another Gilmer "Timing" Belt drives *both* boring spindles at a constant angular velocity —a most important consideration on any metal cutting or grinding operation requiring a high degree of precision or surface finish.

The "Timing" Belt's teeth mesh with axially-cut grooves in the "Timing" Belt pulleys, providing positive grip even when the pulleys are small and the wrap-around or arc of contact is quite limited, as in these two drives. It is not necessary to maintain high initial tension, involving frequent take-up and excessive bearing loads.

Gilmer "Timing" Belts and pulleys are available in stock sizes, or may be made to order for O.E.M. needs. Consult your local NYB&P distributor if you are looking for a *positive* power transmission drive that is light, strong, compact, and requires *no lubrication!*

*Pope Machinery Corporation, Haverhill, Mass.

NYB&P — NEW YORK BELTING & PACKING CO. — Founded 1846

NEW YORK BELTING & PACKING CO. 1 Market St., Passaic, N. J.

America's Oldest Manufacturer of Industrial Rubber Products

New DynAC® stops motors *instantly*...without a ripple!

Here's dramatic proof of the smooth, controlled braking action of the new Westinghouse DYNAC braking controller. Motor stopped *instantly*—without disturbing the water in the glass goblet. "Grabbing" or jerky stops are eliminated with DYNAC braking.

Wherever rapid and/or controlled stopping is required, DYNAC can not only contribute an important safety factor, but it can save you headaches—*and money*—on: (1) production time, (2) material rejects and spoilage, and (3) maintenance expense.

Because it's *completely* electrical, DYNAC requires no mechanical apparatus or motor linkage—it simplifies maintenance. And it comes in *one* compact, spacesaving enclosure. Get the facts on DYNAC's many cost-cutting applications—with every type of standard induction motor. Use the coupon below for more information on DYNAC. J-30200

YOU CAN BE SURE...IF IT'S

Westinghouse

WESTINGHOUSE ELECTRIC CORPORATION
P.O. Box 868, Pittsburgh 30, Pa.

Please send me descriptive bulletins 15-600 and B-6572 on the new DYNAC braking controller.

Name_____

Company_____

Address_____

City_____ State_____

SQUARE D OIL-TIGHT PUSHBUTTONS

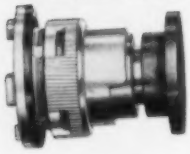
Everybody's Ahead with

THOSE WHO *Build* MACHINES

The *completeness* of Square D's pushbutton line makes a lot of sense to machine builders. Since any operator can be used with any contact block, every conceivable combination can be obtained with a minimum stock of packaged units. Another thing they like...the customer's enthusiastic approval of Square D control on the equipment they buy.

OIL-TIGHT OPERATORS

MOMENTARY CONTACT Guarded button in 7 colors.

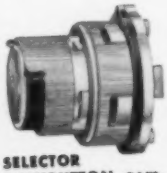


MUSHROOM BUTTON 1⅜" or 2¼". Momentary contact. 7 different colors.

SELECTOR SWITCH 2 or 3 position with 4 different cams.

COIN OPERATED SELECTOR SWITCH Available in same selection as standard type.

KEY OPERATED SELECTOR SWITCH Discourages unauthorized operation.



SELECTOR PUSHBUTTON combines selector switch and pushbutton. 2 or 3 position in red or black.

PADLOCK ATTACHMENT Latch type. For momentary contact buttons. Locks "off" position.

PADLOCK ATTACHMENT Cover type. Prevents depressing button.

MAINTAINED CONTACT ATTACHMENT Used with two operators and one contact block.

SELECTOR SWITCH LOCK-OUT Permits switch to be locked in any one of three positions.

WOBBLE STICK OPERATOR for momentary pushbutton operator. Ideal for emergency stop with pendant station.

NEOPRENE CAP for momentary contact button. Prevents liquids, dust and grit from working into pushbutton operator.

NOW...EC&M PRODUCTS ARE A PART OF THE SQUARE D LINE!

SQUARE D COMPANY

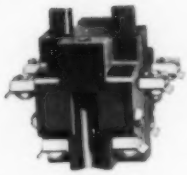
THIS MOST COMPLETE HEAVY DUTY LINE!

AND THOSE WHO *Buy* THEM

Performance and long life rank high with the men who buy and maintain the machines. Square D pushbuttons, designed to JIC and NMTBA standards, have been proven by severe tests involving millions of operations. They offer still other features...generous wiring space and exclusive "Slide and Swing" enclosure covers for easier, faster installations when machine operations are changed.

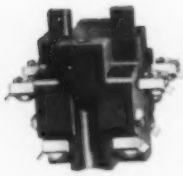
CONTACT BLOCKS and PILOT LIGHTS

Single Pole N.O. and N.C. Contacts.



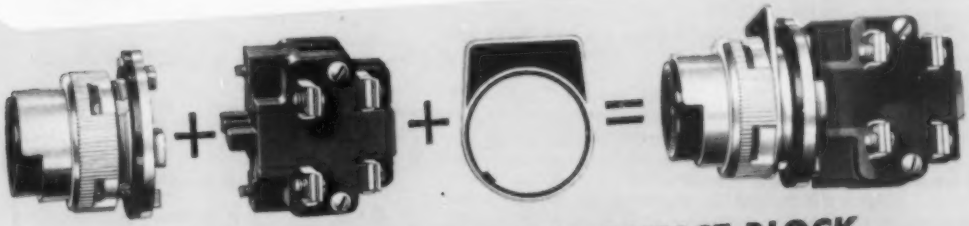
Duplex N.O. and N.C. Contacts.

Tandem Operation. Duplex N.O. and N.C. Contacts with extended stems for combination with another block.

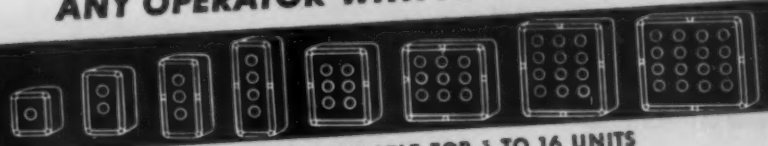


Duplex N.O. and N.C. Contacts with one N.O. circuit closing ahead of the other. Designed for 2-speed or sequence operations.

PILOT LIGHT. Generous illumination and wide-angle visibility. Greatly reduced filament burn-outs. No loosening of lamp under vibration. Six colors—red, amber, green, blue, white, clear.



ANY OPERATOR WITH ANY CONTACT BLOCK



ENCLOSURES AVAILABLE FOR 1 TO 16 UNITS

Dempster-Dumpster—a truck-mounted fork lift designed to handle trash and other bulk materials, shown in dumping position. INSET: "Dacron" is the reinforcement in the V-belts on the 13-inch, 2-groove drive—increasing delivered horsepower, efficiency of hydraulic pump.

How the Dempster-Dumpster's V-belt drive efficiency was increased by premium V-belts reinforced with DACRON

REG. U.S. PAT. OFF.

The lifting and steering power of the Dempster-Dumpster generates from a single hydraulic pump driven by V-belts. To insure dependable, slip-free operation and positive starting at this important spot, Dempster Brothers, Inc., switched to premium V-belts reinforced with Du Pont "Dacron"* polyester fiber. During the six years since the change, the belts have been proving their superiority on hundreds of Dempster-Dumpsters in use throughout the country.

Slippage and stretching have been sharply reduced by the 40% greater strength of belts made with Du Pont "Dacron". Two premium V-belts now do the work formerly handled by three standard belts. The belts remain stable . . . deliver more horsepower from the pump. And the ability of these belts to withstand greater shock loading assures fewer replacements, more efficient, trouble-free operation.

In designing *your* next drive, investigate the advantages of premium V-belts made with "Dacron". They combine the unique properties of the "Dacron" yarn made by Du Pont and the highest skills of the leading V-belt manufacturers. For a list of manufacturers using "Dacron" in premium V-belts, write to E. I. du Pont de Nemours & Co. (Inc.), Textile Fibers Dept., Wilmington 98, Delaware. Premium V-belts shown in above photo were manufactured by the U.S. Rubber Company.

6 REASONS FOR USING PREMIUM V-BELTS REINFORCED WITH "DACRON"

- Transmit up to 40% more horsepower.
- Withstand greater shock loading.
- Longer flex life.
- Cut downtime.
- Low stretch.
- Require less maintenance.

***"Dacron" in V-Belts** DU PONT

REG. U.S. PAT. OFF.

*"Dacron" is Du Pont's registered trademark for its polyester fiber.

BETTER THINGS FOR BETTER LIVING . . . THROUGH CHEMISTRY

High efficiency—low cost

STANDARD-SIZED ROLLED-THREAD SAGINAW ball bearing SCREWS

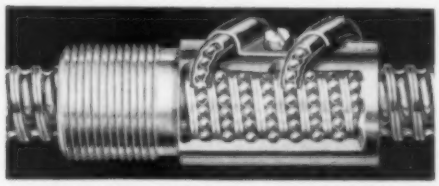
Provide 4 times more efficiency than conventional screws—and require only 1/4 of the power. Reduce size, weight, cost of entire unit.

Here's great news for every manufacturer who uses Acme screws or hydraulic actuators in his product! Saginaw now offers Rolled-Thread *Saginaw b/b Screws* in standard sizes at amazingly low mass-production cost.

In many applications this new rolled-thread type will provide completely adequate performance at a fraction of the cost of machined-thread units.

GIVE YOUR PRODUCTS THESE PERFORMANCE ADVANTAGES AT NO INCREASE IN COST—

- **At least 90% efficiency guaranteed**—compared with 15% to 20% efficiency of Acme screws.
- **Requires less than 1/3 as much torque** as Acme screws for same amount of lineal output.
- **Saves substantially on cost, size and weight** of motors, gear boxes and auxiliary equipment.
- **Far less wear—less maintenance—longer life.**
- **Precision positioning**—free play can be virtually eliminated where necessary.
- **Operates dependably with or without lubrication** at temperatures from −75° F. to +275° F.



New standard Saginaw ball-nut can be furnished threaded or with flange or trunnion-type adaptors for easy application to almost any unit.

ROLLED-THREAD *SAGINAW b/b SCREWS* ARE NOW AVAILABLE IN THESE STANDARD SIZES AND ANY SCREW LENGTH:

Ball Circle Diameter	Ball Size	Lead
.375	.0825	.125
.631	.125	.200
1.000	.15625	.250
1.171	.28125	.41304
1.500	.34375	.47368
2.250	.375	.500
3.000	.500	.660

ROLLED-THREAD *SAGINAW b/b SCREWS* ARE ALREADY BEING SUCCESSFULLY USED IN THESE TYPICAL APPLICATIONS:

- Automatic Garage Doors
- Automobile Seat Adjusters and Window Lifts
- Barber Chairs
- Bumper Jacks
- Circuit Breakers
- Convertible Top Lifts
- Die Table Positioners
- Drill Presses
- Marine Steering Gears
- Welding Machines

--SEND FOR FREE DATA BOOK--

Saginaw Steering Gear Division
Ball Bearing Screw and Spline Operation, Dept. 7J
General Motors Corporation, Saginaw, Michigan

Please send detailed data on your new Rolled-Thread *Saginaw b/b Screws*. I am interested in their application to:

Name—Title

Firm

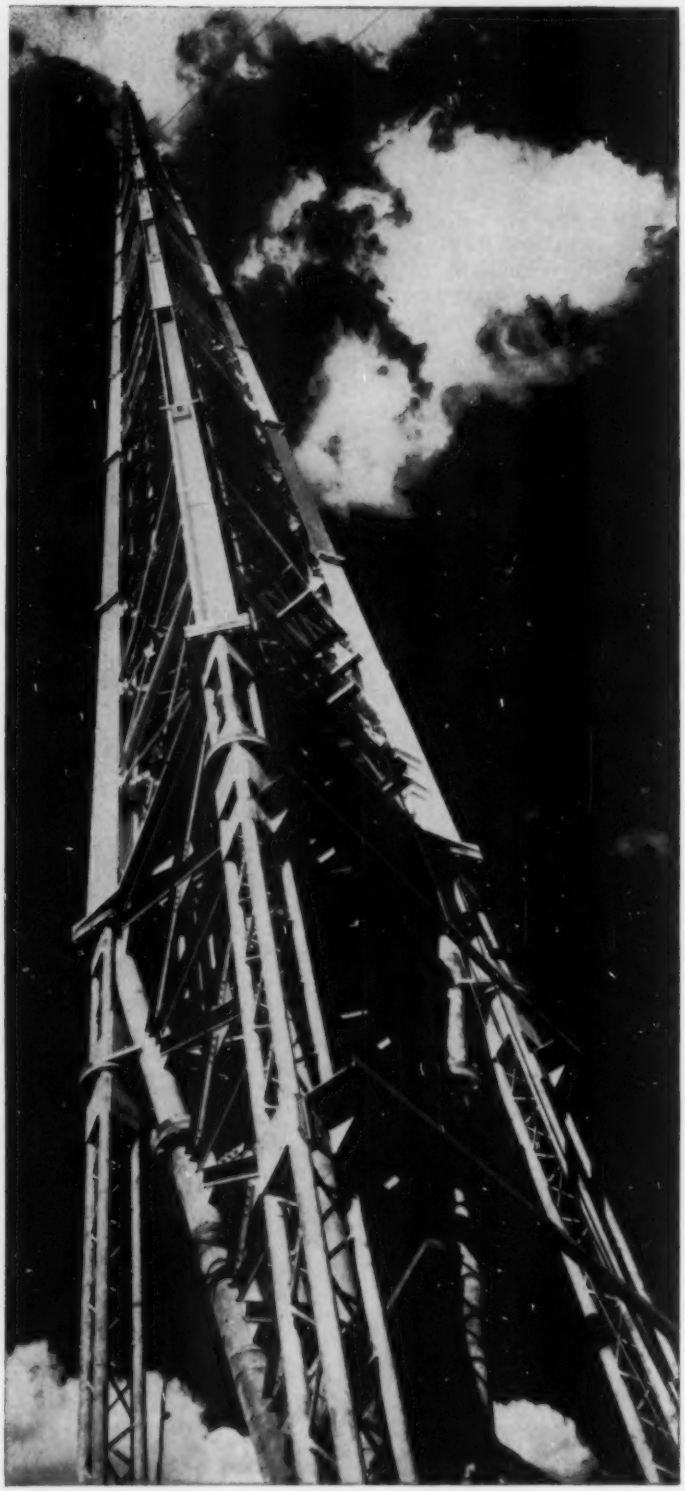
Address

City Zone State

SAGINAW STEERING GEAR DIVISION OF GENERAL MOTORS CORPORATION, SAGINAW, MICHIGAN

Saginaw ball bearing Screws and Splines

You can make it better



WORLD'S TALLEST MAN-MADE STRUCTURE. 100 ft. higher than the antenna atop the Empire State Building, the 1572 ft. television tower of Station KWTA in Oklahoma City dramatically illustrates the advantages obtainable with USS MAN-TEN Steel in structures where both great strength and light weight are imperative.

USS MAN-TEN Steel supplies the needed strength in the intermediate sections of the tower, 1050 ft. in all, where maximum diameter mild rolled steel rounds were simply not strong enough to carry the load of the tower above.

In the topmost bays, mild steel although strong enough was replaced by lighter, smaller sections of USS MAN-TEN Steel to provide greater or equal strength while at the same time reducing wind resistance so that the structure will be safe in winds up to 150 mph.

RUGGED IS THE WORD. Used in the body liner plates and canopy guard of this 34-ton Rear Dump built by Euclid Division, General Motors Corporation, Cleveland, O., USS TRI-TEN Steel provides 50% greater strength, 60% greater toughness and three times the resistance to atmospheric corrosion of structural carbon steel. And what is of particular importance in equipment like this, that must be able to operate all year around, is TRI-TEN Steel's ability to withstand the shock and impact of heavy, high speed loading even at sub-zero temperatures.

with USS High Strength Steels

In USS High Strength Steels, design engineers have at their command three service-tested steels that will permit them to materially increase the efficiency and economy of machinery, equipment and structures at little or no increase in first cost . . . and frequently, at a saving.

All three of these famous *"steels that do more"*—USS Cor-Ten, USS Man-Ten and USS Tri-Ten—have a 50% higher yield point than ordinary carbon steel. All have better corrosion resistance and offer greater resistance to wear, fatigue and impact. Each, however, has specific superior properties that should be considered in determining its selection.

USS Cor-Ten Steel, for example, is distinguished by its superior resistance to atmospheric corrosion—4 to 6 times that of carbon steel. USS Man-Ten Steel is intended for weight reduction by means of greater strength in moderate forming applications, with enhanced resistance to abrasion and atmospheric corrosion. USS Tri-Ten Steel's outstanding characteristics are excellent weldability and resistance to shock at low temperatures.

Used singly or in combination, these steels can advantageously replace carbon steel to increase the strength and durability of vital parts *without* increasing their weight. Or when the use of thinner sections is feasible, they can (1) reduce equipment weight without reducing its strength, or (2) increase the size and capacity of equipment without increasing total weight or the power required to move it.

• • •

You will find our 174-page *"Design Manual for High Strength Steels"* extremely useful in applying the benefits of these steels to your product. Send for free copy—simply write on your company letterhead to United States Steel Corporation, Room 5319, 525 William Penn Place, Pittsburgh 30, Pa.

HARD-WORKING FARM EQUIPMENT lasts longer, is more dependable when built with USS Cor-Ten Steel. Here used in the main axle and tractor hitch frame of the famous John Deere No. 12-A Combine, USS Cor-Ten Steel gives these vital parts maximum strength, maximum toughness with no increase in weight and at the same time ensures high fatigue resistance—50% greater than that of plain carbon steel. Racking and twisting strains that could easily cause a breakdown are safely absorbed by Cor-Ten Steel's high endurance limit—and the equipment stays on the job.

STRENGTH AND TOUGHNESS are prime requisites in boom boats like this. Used by logging firms to buck logs in the sawmill pond to the log haul-up, these busy little vessels receive very rough treatment, are frequently squashed between the huge logs they handle. To ensure all the strength possible in the hull, sides and bottom are plated with Cor-Ten Steel, welded both inside and out. Cor-Ten Steel's greater abrasion resistance and its high resistance to corrosion also play an important part in prolonging life. (Built by the Ilwaco Boat Works, Ilwaco, Wash.)

1933 USS HIGH STRENGTH STEELS 1956 — 23 YEARS OF PERFORMANCE

UNITED STATES STEEL CORPORATION, PITTSBURGH • AMERICAN STEEL & WIRE DIVISION, CLEVELAND
COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO • NATIONAL TUBE DIVISION, PITTSBURGH
TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA. • UNITED STATES STEEL SUPPLY DIVISION, WAREHOUSE DISTRIBUTORS
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

USS HIGH STRENGTH STEELS

USS MAN-TEN • USS COR-TEN • USS TRI-TEN

UNITED STATES STEEL

CONTROL FLUID FLOW

with Micrometer Accuracy

HANNA Flo-Set VALVES

For AIR, OIL and WATER operation to 250 p.s.i.
SIZES ¼" • ⅜" • ½" • ¾"
TEMPERATURES to 250°F

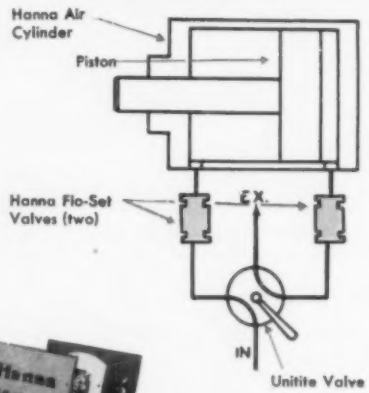
Hanna Flo-Set Valves are used to control cylinder piston speeds and operating speeds of many types of fluid actuated mechanisms. They are able to handle air, oil, water and many gases. When used with cylinders, these valves permit independent adjustments of forward and return piston speeds. The diagram at the right shows a typical circuit. Flo-Set Valves make the operation of air cylinders smoother and make cushioned cylinders more effective by building up essential back pressure.

Fluids pass unobstructed in the direction of the arrow on Hanna Flo-Set Valves. In the opposite direction, flow can be controlled from zero to full pipe capacity. One valve can be set to an infinite number of controlled flow positions. Once set, the position can be held by means of a locking collar. Established flow positions can be reset by using the micrometer graduations which accurately measure flow as a percent of full pipe capacity.

One revolution of the aluminum valve body will change the flow rate from zero to full capacity. No tools are necessary! In addition to the standard ¼", ⅜", ½" and ¾" sizes, there is a ¼" Jr. model, without micrometer graduations or locking collar, for light piping and tubing.

Typical Cylinder Circuit Using Hanna Flo-Set Speed Control Valves

Hanna engineers will gladly recommend circuits to help you with your applications.



Consult your classified telephone directory or Thomas' Register for your nearest Hanna representative. Write for Hanna Valve Catalog 254 and Flo-Set Valve Bulletin 253A.

Hanna Engineering Works

HYDRAULIC AND PNEUMATIC EQUIPMENT . . . CYLINDERS . . . VALVES . . . RIVETERS

1763 Elston Avenue • Chicago 22, Illinois

HIGH-TEMPERATURE INSULATION?

silicone rubber retains dielectric strength at elevated temperatures

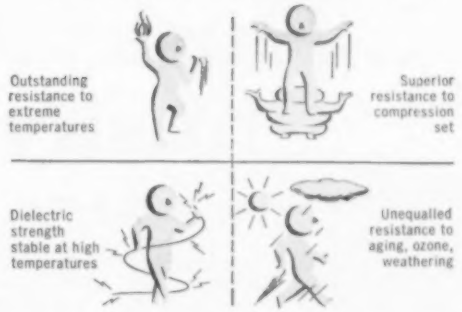
Need *high-temperature* insulation? General Electric silicone rubber insulation maintains exceptional stability under heat. For example, it's ideal for wire and cable where overloads or space limitations dictate a heat-resistant dielectric. Cables have been redesigned with it to carry nearly twice the current *—with no increase in size.* G-E silicone rubber makes Class H insulation possible—and greatly improves Class B.

Where can YOU use G-E silicone rubber?

There's a kind for almost every requirement, classified according to dominant property for easy selection and specification. For example: Class 300 offers the best recovery after compression *of any known rubber!* Class 500 provides flexibility *at 150 F below zero!* Which class is best for *you?*

For more details on G-E silicone rubber, see your "Sweet's Product Design File"

G-E silicone rubber provides...


Outstanding resistance to extreme temperatures
Superior resistance to compression set
Dielectric strength stable at high temperatures
Unequalled resistance to aging, ozone, weathering

Send today for a NEW, REVISED "LIGHTNING SELECTOR"!

Progress Is Our Most Important Product

GENERAL ELECTRIC

SILICONE PRODUCTS DEPARTMENT — Section 61-4D
GENERAL ELECTRIC COMPANY — Waterford, New York

Please send me, at no obligation, technical data on G-E silicone rubber, including a newly revised "Lightning Selector" and up-to-date list of fabricators

Name _____ Position _____

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Street _____

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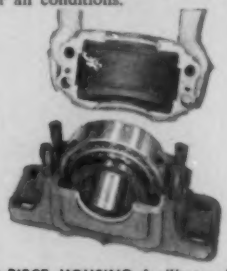
IN CANADA: MAIL TO CANADIAN GENERAL ELECTRIC COMPANY, LTD., TORONTO

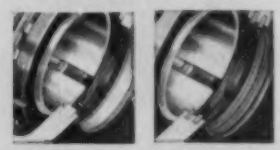
MORE FACTS on why more and more leading manufacturers choose Link-Belt bearings

Constant, heavy loads as produced by this high-capacity belt conveyor call for life-long alignment as built into Link-Belt roller bearing blocks.

SELF-ALIGNING ROLLER BEARING is self-contained and adjusted at the factory, needs no shims or alignment rings at installation. Design assures free rolling under all conditions.



TWO-PIECE HOUSING facilitates installation, inspection and disassembly. Both base and cap are machined as a unit for perfect match. The cap is doweled to the base for proper positioning.



CHOICE OF SEALS. Left, contact-type felt seals for grease lubrication and dirty conditions—right, spiral labyrinth steel seals for oil or grease lubrication and heat conditions.

Husky bearings in husky housings

--the choice for industry's big loads and toughest applications

BRING on your sudden loads and impacts, shaft deflection and misalignment. A heavy-duty, high-capacity Link-Belt self-aligning roller bearing takes such punishment in stride . . . adjusts immediately in all directions . . . delivers a high load at relatively moderate cost.

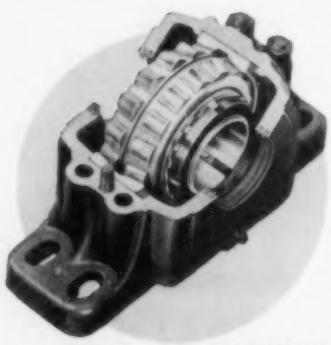
This simple, economical, easy-to-install "package" incorporates the popular Link-Belt self-aligning roller bearing in a durable cast iron housing with provision for lubrication. It's completely sealed to prevent entrance of dirt or loss of lubricant. The self-aligning roller bearings have internationally standardized boundary dimensions and are available everywhere.

For all your bearing needs, look to industry's most complete line of ball and roller bearing blocks. At any of 40 Link-Belt offices, you can get a copy of data Book 2550.

13,991-A

LINK-BELT

Ball and Roller Bearings



Series 6800, 6900, 7800, 7900 roller bearing blocks

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office: New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World.

In the John Bean "ROTOMIST"..... WEBSTER Hydraulic Motors

for remote power

• Maximum effectiveness of this John Bean "ROTOMIST" shade tree sprayer depends, in large part, on the instant response of its hydraulically operated turntable. This turntable must be able to rotate 360° in either direction.

To assure maximum speed of response, the hydraulic circuit governing the operation of this turntable is equipped with WEBSTER'S Model MHES Hydraulic Motor.

Whether your particular requirement for a hydraulic pump or motor is speed of response, shock resistance, dependable performance, or compactness for installation in a crowded area, WEBSTER has the answer. And WEBSTER gives you the widest possible selection—over 100 models of gear-type pumps ranging in capacities from 1/5 to 30 gpm, for pressures up to 1500 psi and speeds to 3600 rpm, and hydraulic motors up to 20 hp at 2000 rpm.

Their quality construction features and moderate price make a combination which will pleasantly surprise you.

OIL HYDRAULICS DIVISION

WEBSTER RACINE **ELECTRIC** WISCONSIN

FREE 12-PAGE CATALOG

contains complete information on WEBSTER'S complete line of over 100 different positive displacement gear-type pumps and fluid motors. Write for your free copy today.

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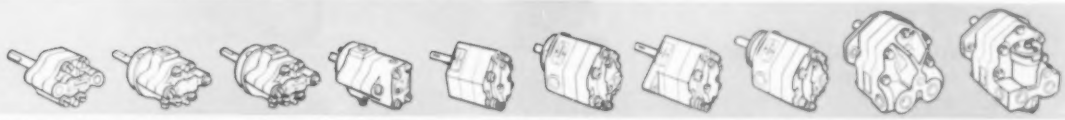
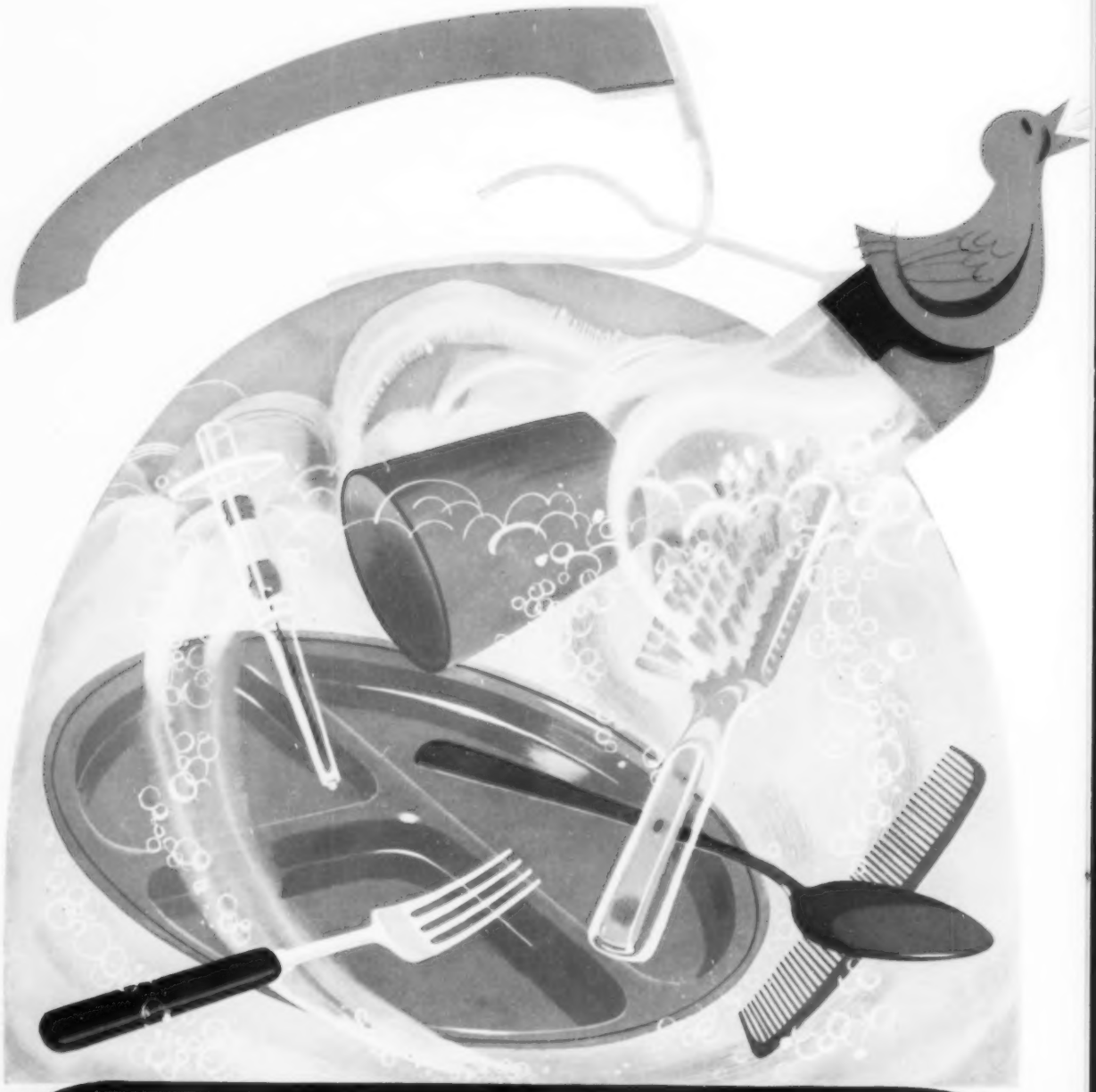


MANUFACTURERS OF A COMPLETE LINE OF OIL HYDRAULIC PUMPS FROM 1/5 TO 30 GPM CAPACITY

C Y M



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Methyl – Styrene Molding Compounds

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Announcing New Thermoplastic Molding Compounds...CYMAC

—based on Methylstyrene Monomer

NOW AVAILABLE—two compounds so heat resistant that products molded from them show no distortion after repeated, extended immersion in boiling water.

1. CYMAC 400 Polymethylstyrene—offers unusual heat resistance *plus* all the desirable properties of polystyrene, including excellent electrical properties, clarity, luster, and unlimited range of transparent and opaque colors.

2. CYMAC 201 Methylstyrene-Acrylonitrile Copolymer—offers better toughness, chemical and craze resistance than CYMAC 400—*plus* heat resistance, clarity, luster, and wide color range.

Both of these new molding compounds provide the added value of remarkable heat resistance at costs no greater than competitive materials.

These new methylstyrene thermoplastics are made possible by revolutionary new processes developed by Cyanamid. They will help you upgrade existing molded products, and find new applications in consumer and industrial fields.

Turn opportunity into reality NOW. Write or call today for complete information and samples.

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PLASTICS AND RESINS DIVISION 30 ROCKEFELLER PLAZA, NEW YORK 20, N. Y.

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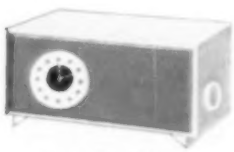
For automotive parts

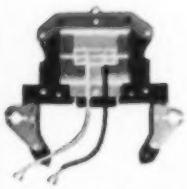


For radio cabinets

For refrigerator parts

For business machine housings and parts

For pen barrels



For electrical parts

For fan blades

For battery cases

For wall tiles

. . . and hundreds of other products

How papers by Mosinee make products safer, more efficient

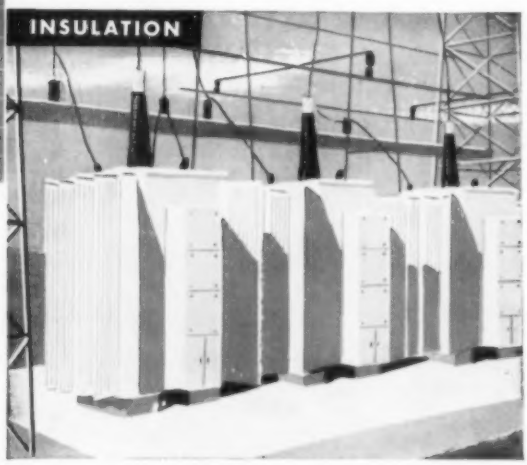
From cooling rooms to heating homes or guarding electrical apparatus – Mosinee specially developed papers help do the job better.

IN these and hundreds of other cases involving insulation, fabrication, lamination, processing or packaging — Mosinee papers play an important part in getting optimum results with minimum trouble and expense.

It will pay you to find out how Mosinee experts cooperate with industry to develop specialized papers. Current applications of Mosinee papers will suggest immediate ways in which you can make substantial savings in time and money. Write today for complete information.

Evaporative cooler pads for room coolers are made from Mosinee controlled paper. A high rate of moisture absorption with wet strength are two of the critical properties of this highly specialized paper. In addition, this paper must be adapted to easy slitting and expanding in the conversion operation for pad construction. Here's typical Mosinee precision control at work.

Mosinee flame-resistant papers increase safety factor of filters employed in warm air heating systems. The process of making these papers flame-resistant was developed by Mosinee technicians. This process, applicable to many types of paper, may help you solve a product or processing problem.



Special analysis Mosinee papers improve performance of electrical components. These electrical insulation papers must be closely controlled to provide a low ash and chloride content. They are used extensively as layer insulation between turns of field coils and in transformers — from the smallest to one of world's largest. Ask about Mosinee papers for your electrical requirements.

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Today, there's only one *best* way to order "O" Rings, and get true compression—molded quality, mass-produced, delivered in a hurry, in quantities to satisfy anyone's needs!

LINEAR, with an exclusive high-speed process, produces ROTO-MOLDED "O" Rings with precise tolerances, absolute uniformity, flash-free surface and pre-stretched grain structure—at prices that command consideration.

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LINEAR ROTO-MOLDED perfect circle "O" Rings are produced in a variety of standard sizes and materials, plus special types and sizes for specific applications.

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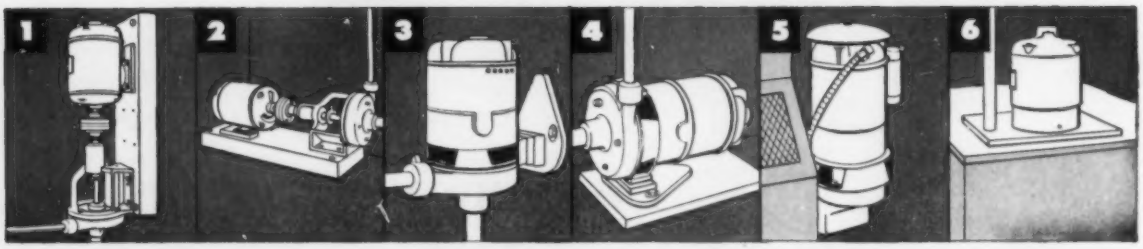
ALLIS-CHALMERS

PUMPS for Designers

One Pump 6 Mounting Methods



Base mounted, vertical | Base mounted, horizontal | Close-coupled, vertically mounted | Close-coupled, horizontally mounted | Tank wall mounted | Submerged mounted

Makes Easier Designing for You

YOU CAN SOLVE MANY DIFFICULT ARRANGEMENT problems easily by standardizing on Allis-Chalmers pumps. You get a single set of operating characteristics in four different models which can be installed six different ways.

Choose the pump for exactly the performance characteristics you need; then use the drive and mounting method best suited to your application. Design problems are simplified . . . designing costs and time reduced.

Engineering Assistance

Your Allis-Chalmers representative is an experienced, highly qualified specialist who will give you full cooperation every step of the way from drawing board to finished product. Sometimes he can make valuable suggestions which will result in a simpler, more effective product. Next time you have a pump problem, call your Allis-Chalmers District Office or write Allis-Chalmers, Milwaukee 1, Wisconsin.

A-4599

Electrifugal is an Allis-Chalmers trademark.

For literature on Allis-Chalmers FHP pumps, ask for bulletins 52B7529 and 52B6691 . . . *Electrifugal* pumps, Bulletin 52B6083 . . . Vertically Mounted pumps, Bulletin 52B6975. Write Allis-Chalmers, Milwaukee 1, Wisconsin.

AC ALLIS-CHALMERS

ALLIS-CHALMERS

INTRODUCING GRAPH-AIR...

a tougher, more versatile graphitic tool steel that air-hardens at temperatures 200° to 300° lower with less distortion!

NO facilities for oil-quenching—or other relatively costly heat treating processes? Need a finer air-hardening tool steel? Then specify *Graph-Air,* newest steel resulting from the Timken Company's pioneering in fine alloy steels. Latest addition to our line of quality graphitic tool steels!

Graph-Air tool steel air-hardens at temperatures of 1450°F to 1550°F—200° to 300° lower than most other air-hardening tool steels. And because Graph-Air *is* air-hardened, there's less distortion, easier heat treating control, less decarburizing. As a result, Graph-Air can be made into *more intricate sections.* Graph-Air is a tough air-hardening steel, too—made to order for such demanding applications as blanking dies, or any tool steel part which must take hard abuse.

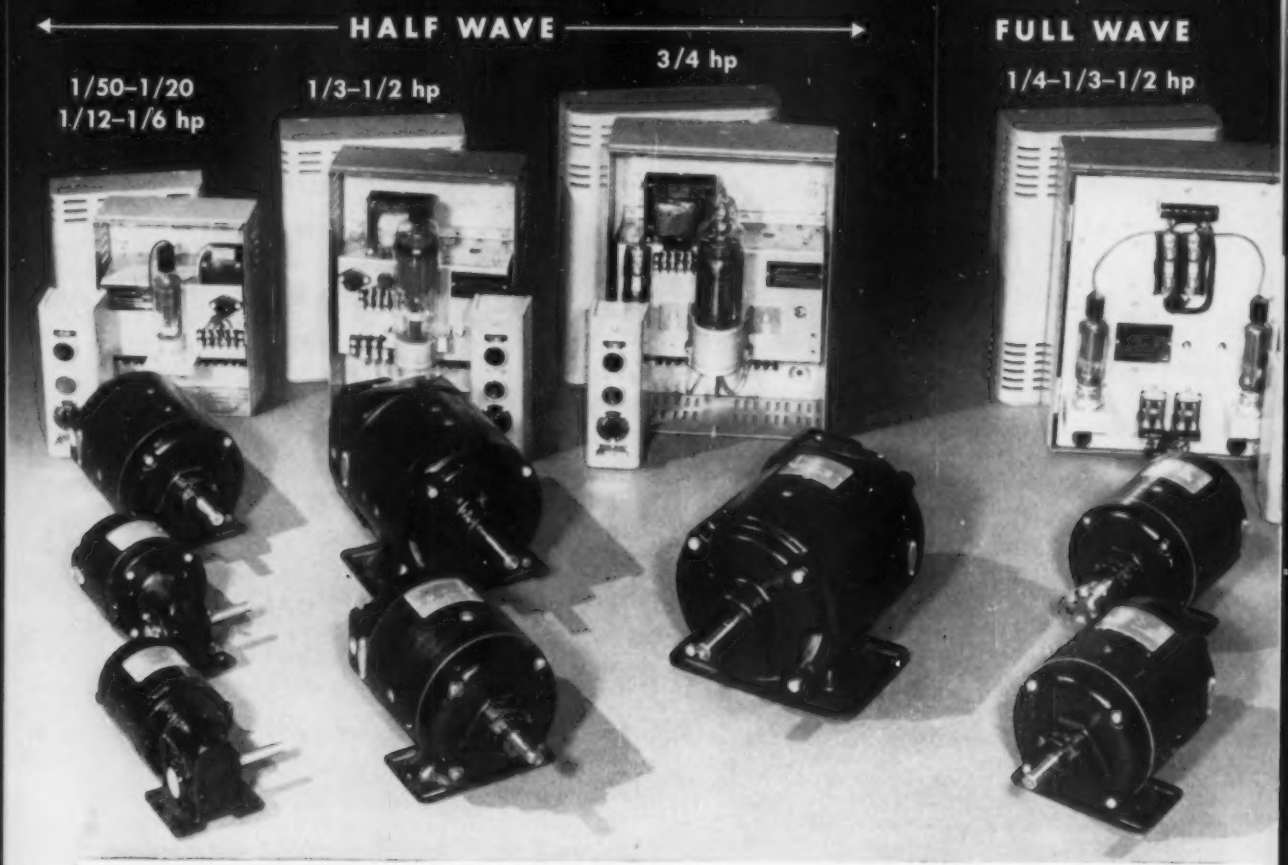
Besides all the advantages of air-hardening —economy, less drastic reactions to quenching, less tendency to scale—Graph-Air offers greater wear, machinability and stability. Like Graph-Mo, Graph-Air will outwear other tool steels, because of the uniform diamond-hard carbides in its structure. And Graph-Air machines 30% faster. The free graphite in its structure acts as a built-in lubricant. And Graph-Air stays *accurate longer,* is fully as stable as other Timken Company graphitic tool steels, which are the most stable tool steels made!

Growing out of the Timken Company metallurgists' long experience with fine steel making, Graph-Air—the *new* graphitic tool steel that can be air-hardened at *low* temperatures—will be available in both solid and hollow bar sizes. For more information, write: The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO".

TIMKEN *Fine Alloy* **STEEL**

TRADE-MARK REG. U.S. PAT. OFF.

SPECIALISTS IN FINE ALLOY STEELS, GRAPHITIC TOOL STEELS AND SEAMLESS STEEL TUBING



A DRIVE TAILORED TO EVERY JOB is the achievement of General Electric engineers who designed the new fhp Thymotrol drive line. Here are examples of this versatility:

Three panel sizes now cover the fhp range, making smaller ratings more compact, more economical than ever before.

Full range of ratings

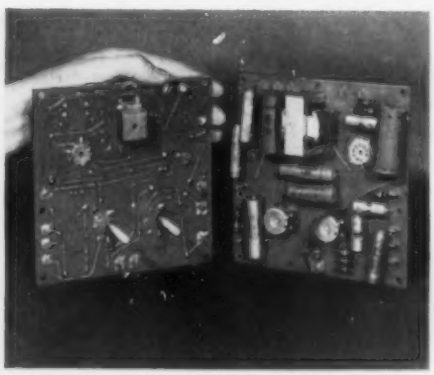
- Horsepower: 1/50 to ¾†
- Power supply: 220 v a-c, 50/60 cycles
- Speed range: 20 to 1
- Speed reg.
  (NL to FL): half-wave — 3%, full-wave—5% (adjustable to flat at any specific speed)

†Plus a full line of integral-hp drives.

Building-block design—you get the exact performance you want by selecting any combination of these optional features:

- Reversing operation
- Jogging (pre-set or run)
- Dynamic braking
- Tachometer follower
- Overload relay protection
- Tube warm-up protection

ONE-TUBE DESIGN of G-E half-wave Thymotrol drives minimizes tube maintenance. This type drive is suitable for most adjustable-speed jobs.



PRINTED CIRCUITRY, DIP SOLDERING are effective techniques which permit new lower General Electric prices. Exhaustive tests prove the sturdiness of this construction for industrial use.

PLUG-IN PANEL BOARD can be quickly removed for maintenance or replacement to minimize downtime—a must on such jobs as production conveyors.

GENERAL ELECTRIC ANNOUNCES . . .

NEW full line of fractional-horsepower G-E Thymotrol* adjustable-speed drives—more compact, more rugged, more reliable, easier and more economical to maintain, yet priced up to 18% below previous models

General Electric announces a completely re-designed line of fractional-hp Thymotrol adjustable-speed drives—*designed to save you up to 18% over prices of previous models.* These versatile new drives are applicable to conveyors, machine tools, in fact, to almost every small machine whose performance can be improved by adjustable speed.

SELECT JUST THE DRIVE YOU NEED —AND SAVE MONEY!

Biggest cost-saving for you with new G-E Thymotrol drives is that you buy only as much drive as you need. For some applications, you'll want only the basic half-wave drive: motor, simple one-tube control, and control station. For more complex jobs, you can select any combination of seven different optional accessories to provide desired performance. To further match drive to job, these popular half-wave drives come in three panel sizes.

For rapid acceleration of high-inertia loads, for extra-smooth performance, or for flat speed-regulation adjustment, you'll want the new full-wave Thymotrol drive, with still other optional features.

NEW DESIGN IS SIMPLE, RELIABLE

In designing new G-E Thymotrol drives for mass production, G-E engineers have also included many new features for longer life, lower operating costs, increased reliability:

Plug-in panel boards on half-wave units can be quickly removed without disturbing customer wiring for fast inspection, repair, or replacement, minimizing downtime.

Printed circuitry and dip soldering result in more compact units which simplify your design problems. Shock and vibration tests show this construction really stands up in industrial use. Parts replacement is simple using soldering iron and pliers.

20:1 speed range is now standard on all ratings. And operator can turn machine to full "off" with speed-control knob.

High tube reliability—all tubes on G-E Thymotrol drives are fully guaranteed for one year, usually last far longer.

SIMPLE PACKAGED DRIVES OR ENGINEERED MULTI-MOTOR SYSTEMS

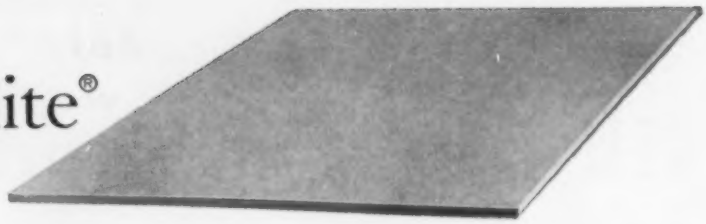
Whatever your adjustable-speed needs, from packaged single-motor drives to specially engineered multi-motor systems, you'll find the answer —*at new low prices*—at General Electric. See your G-E Apparatus Sales representative today. Or write for Bulletin GEA-6519 to Sect. 791-3, General Electric Co., Schenectady 5, N. Y.

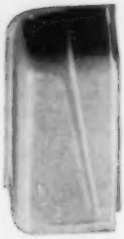
*Trade-mark of General Electric Co.

Progress Is Our Most Important Product

GENERAL ELECTRIC

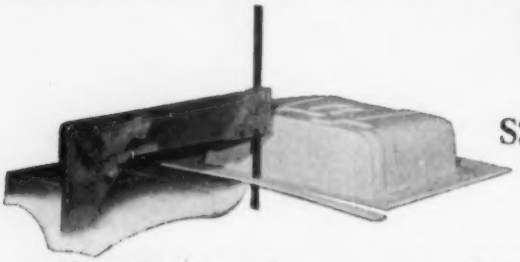
U.S. Royalite®





molds to any contour or detail, functional or decorative... can be quickly tooled by means of cast molds

can be riveted, sawed, machined, etc... has colorful, sales-appealing beauty

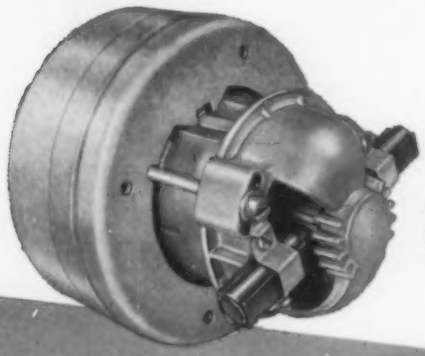


AND IS PLENTY TOUGH!

Beauty and strength are yours in Royalite's exclusive compounding of thermoplastic fortified with rubber as in the case of the above soon-to-be-announced portable dictating machine. Economy, too—dies can be made of wood (for prototypes), resin or metal, depending on the production run. Royalite comes in sheets in a choice of many built-in colors, grained and smooth finishes. Let us show *you* why Royalite is *right* for your product. Write or phone United States Rubber Company, 2638 N. Pulaski Road, Chicago 39, Ill.

US RUBBER United States Rubber

standard in its field the world over...



Turbine for canister-type vacuum cleaner

Equal Quality Assured For YOUR Motor-Driven Products

The outstanding quality and performance of the Lamb Electric vacuum cleaner motor, shown above, result from proper design and careful manufacture, by personnel having years of experience in the small motor field.

High quality and controlled costs go hand-in-hand because our company is equipped and organized to *custom manufacture* on a volume basis.

Ask us to demonstrate the benefits of Lamb Electric special application motors for *your* products.

THE LAMB ELECTRIC COMPANY • KENT, OHIO

In Canada: Lamb Electric—Division of Sangamo Company Ltd.—Leaside, Ontario

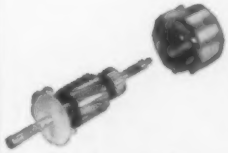
Lamb Electric

SPECIAL APPLICATION FRACTIONAL HORSEPOWER **MOTORS**

Ruggedly constructed equipment motor.

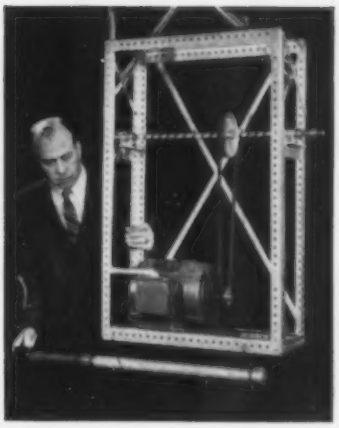
Lightweight motor for portable devices.

Intermittent high torque aircraft motor.



Motor parts for household appliances.

If you are interested in any of the above motors write and we shall be glad to send full information.



TOMORROW:

A standard motor that can survive infinite heat

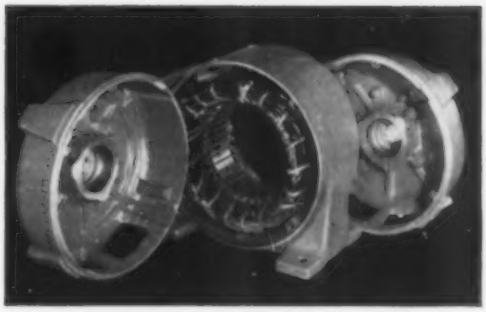
The new Life-Line A is another step closer

Westinghouse is working on tomorrow's motor today. Investigating new materials—testing existing motor designs.

No standard motor today can survive the ultimate test shown here. But we do know that the new Life-Line® "A" can operate under higher temperatures than ever before. It has stronger insulation and better bearing protection than any other motor on the market. It's industry's closest approach to a standard motor that is absolutely heatproof.

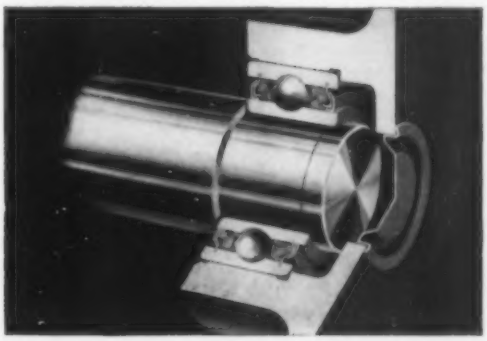
Your Westinghouse sales engineer can show you many additional reasons why the Life-Line "A" is industry's most advanced and preferred motor. Call him today.

J-21926



New fortified insulation includes exclusive Bondar, Bondite and Mylar*—three good reasons why the Life-Line "A" is so resistant to heat or any other motor contamination.

*DuPont Registered Trade-Mark



Two outer seals of new 4-way sealed bearing act as flingers and literally throw off damaging contaminations. Inner seals, attached to outer bearing race, are stationary and form a positive labyrinth.

WATCH WESTINGHOUSE!

WHERE BIG THINGS ARE HAPPENING TODAY!

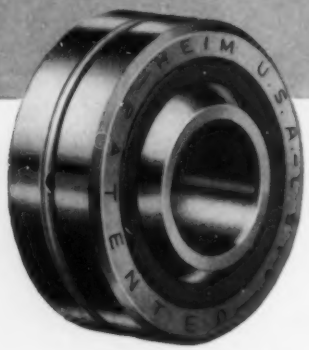
HEIM

has a bearing

FOR YOU

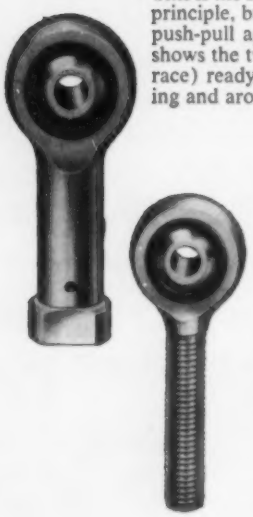
With a half century of experience in the anti-friction bearing industry, it was only natural to expect from The Heim Company origination of the modern methods in producing Unibal, the single ball spherical bearing.

Heim pioneered not only in the perfecting and manufacture of the spherical bearing, but in its introduction to American, as well as foreign, manufacturers.



The single ball (Unibal) construction, because of its free action, compensates for shaft misalignment and deflections in all directions. There is ample provision for lubrication around the ball, and the greater supporting area carries heavier loads.

This is the Heim Unibal Rod End. It operates on the same principle, but is mounted in a suitable housing for use in push-pull applications. The exploded view, at the right, shows the two bronze bearing inserts (the race) ready to be expanded into the housing and around the ball.



Heim Unibal Spherical Bearings are available in a wide range of stock sizes, the Rod Ends are made in both male and female types, and complete stocks are carried by bearing distributors throughout the country.

It is not only the low price of the Unibal Rod End, but the simplicity of attaching it that bring the overall cost down. Many applications require only a drilled and tapped hole for the male rod end — or a drilled hole, with a bolt or screw for the female type.

Please write for complete catalog and name of nearest Direct Factory Representative or Distributor. Heim Unibal is also manufactured, under license, in England, Germany, Switzerland and other European countries.

THE HEIM COMPANY
FAIRFIELD, CONNECTICUT

SELF ALIGNING
BALL BEARING FLANGE UNIT

SELF ALIGNING
BALL BEARING PILLOW BLOCK

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FLANGED BALL BEARING

ROLLER BEARING
FLANGE UNIT

ROLLER BEARING
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FLANGED ROLLER BEARING

CENTER FLANGE, SEALED,
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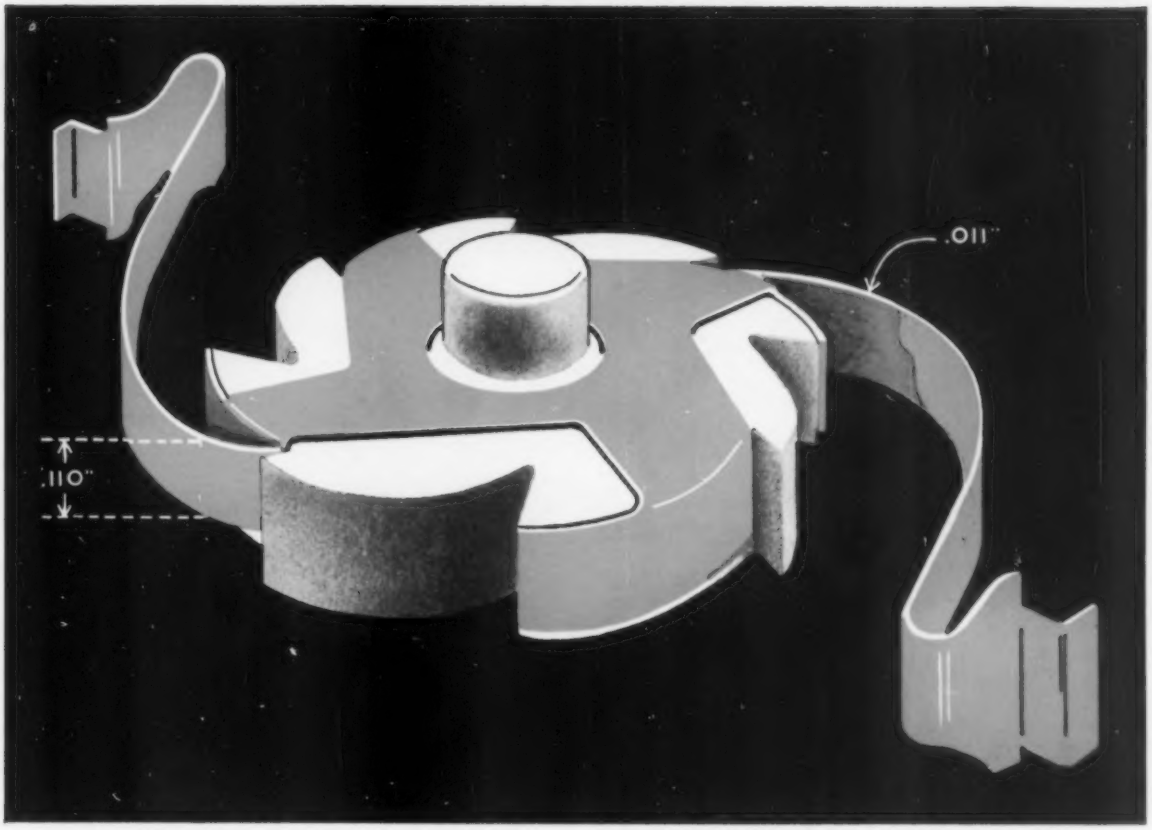
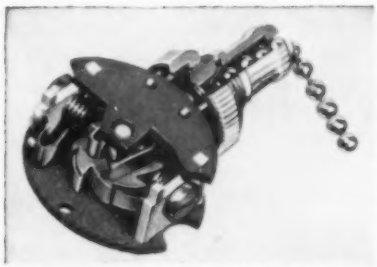


Enlargement showing the contact springs at the "heart" of one model of the Levolier® switch mechanism. Levolier switches are used in industrial and commercial lighting, in heavy-duty industrial sockets, in appliances, fixtures, etc.

The Anaconda alloy tailored for this punishing service actually costs less



Cutaway of Levolier Switch No. 41 shown approximately actual size.

THE PROBLEM: The McGill Manufacturing Company, Inc., Valparaiso, Indiana, was interested in a desirable substitute for a premium copper alloy used in contact springs for their widely known Levolier switch mechanisms. Unexcelled quality had to be maintained with a new alloy that would help hold prices against rising costs. As these switches are designed for long service and heavy-duty industrial service, the spring material has to be tough and durable.

THE SOLUTION: In 1952, McGill discussed the problem of an alternate spring material with a metallurgical engineer from The American Brass Company. After an analysis of the requirements, a special Anaconda alloy was offered – Ambronze-422, rolled to spring temper.

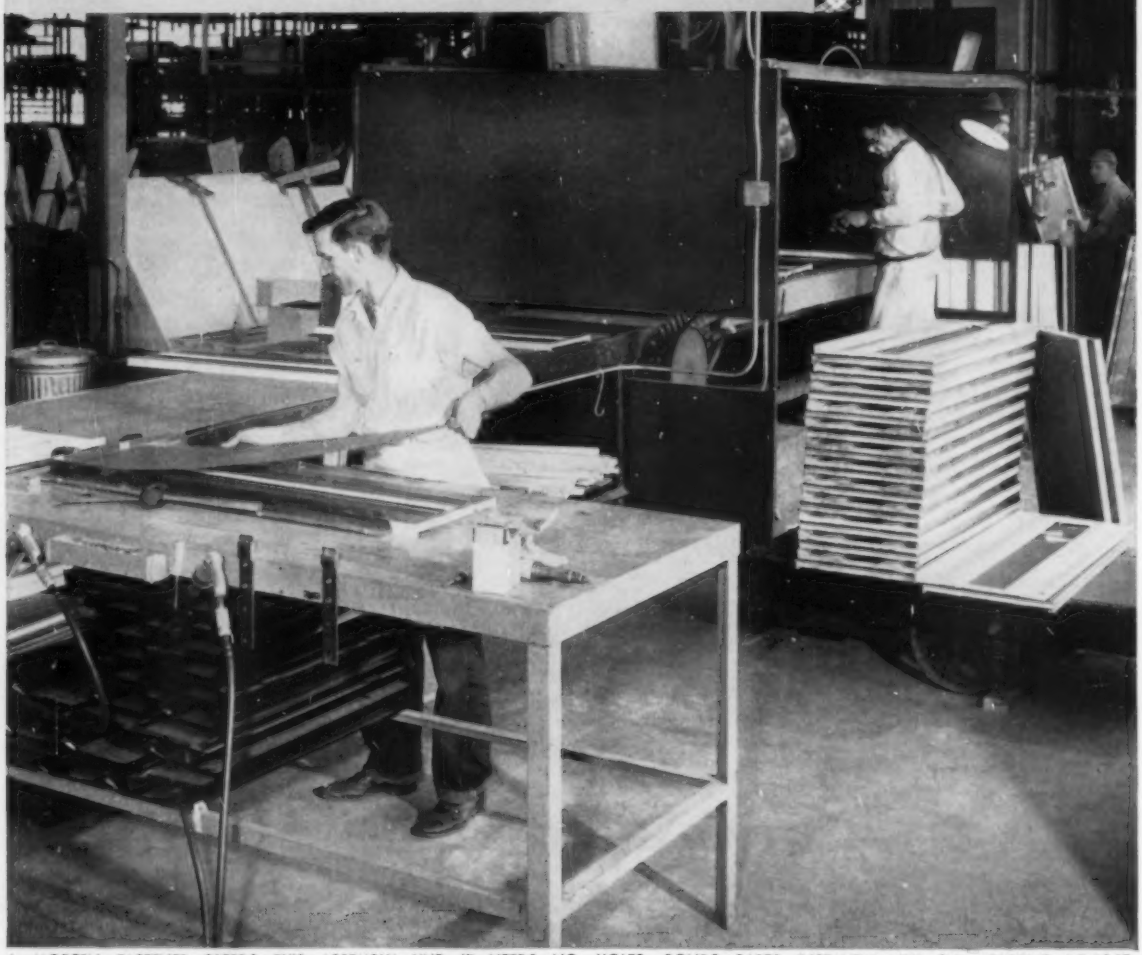
Samples were prepared and tested by McGill and Underwriters' Laboratories. The material performed satisfactorily in standard tests—current carrying capacity, 6 amps at 125 volts d.c.—readily exceeded the requirements of 75,000 cycles, or 150,000 individual operations.

In production, the new Anaconda alloy also performed satisfactorily. It was necessary to make only one minor die-forming change. McGill received a desirable saving in material costs – product quality remained high—and the material was available as needed to maintain production.

FREE TECHNICAL SERVICE: This is another example of the Anaconda technical service available to metal users. Sometimes a new alloy is required—other times a variation of a standard alloy will do the job. The Technical Department of The American Brass Company, through its day-to-day work with a wide variety of metal problems, offers a tremendous breadth of experience, which is at your disposal. See your American Brass Company representative or write: The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ontario. 5664

ANACONDA® COPPER AND COPPER ALLOYS

See what adhesives are doing today!



A MODERN FASTENER SPEEDS THIS ASSEMBLY LINE. IT NEEDS NO HOLES, BONDS PARTS INSTANTLY. IT'S 3M ADHESIVE EC-1357.

Simplifying the assembly line

A 3M adhesive is helping to create 50 shelves per hour right before your eyes. By bonding parts instantly, EC-1357 simplifies this assembly line to just four fast operations.

One worker puts metal frames and fiberboard sheets on a conveyor moving 9 feet per minute. The second sprays EC-1357 on both as they pass by. The third positions the boards on the frames. They pass under a pressure roller and the bond is complete. There are no extra fastening steps.

Instantly EC-1357 bonds board to frame so strongly that the fiberboard will delaminate if you try to remove it. A fourth man installs molding. The shelves are ready to ship immediately.

Hundreds of other 3M adhesives serve industry in a thousand varied uses.

SEE WHAT ADHESIVES CAN DO FOR YOU!

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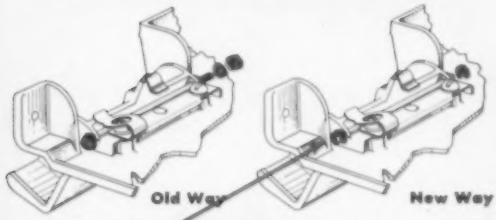
5 Waldes Truarc rings eliminate parts, speed assembly, in light, compact dictating machine

Edison's "V. P." Voicewriter

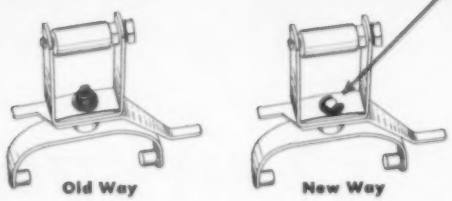
Edison engineers built this new dictating instrument for small size, light weight, and rugged performance. Waldes Truarc rings replace old fashioned fasteners, cut production costs; keep unit light, compact, and achieve faster more economical assembly.

Disc Lever Cover Assembly



Two Waldes Truarc E-Rings (Series 5133) replace nut, bolt, washer assembly, eliminate one component and assure precise alignment of parts. Truarc rings facilitate pivoting without binding. Production assembly time is decreased.

Lift Bracket and Fork Assembly



A single, easily assembled Waldes Truarc E-Ring (Series 5133) replaces nut-bolt-washer fastening. Free pivoting is assured, one component eliminated, labor and material costs reduced.

Clutch Plate Assembly

Two Truarc E-Rings eliminate staking operation, prevent damage to spring coil. Simple assembly operation speeds production, eliminates rejects, reduces labor and material costs.

Whatever you make, there's a Waldes Truarc Retaining Ring designed to improve your product... to save you material, machining and labor costs. They're quick and easy to assemble, and they do a better job of holding parts together. Truarc rings are precision engineered and precision made, quality controlled from raw material to finished ring.

36 functionally different types... as many as 97 different sizes within a type... 5 metal specifications and 14 different finishes. Truarc rings are available from 90 stocking points throughout the U. S. A. and Canada.

More than 30 engineering-minded factory representatives and 700 field men are available to you on call. Send us your blueprints today. Let our Truarc engineers help you solve design, assembly and production problems, without obligation.

For precision internal grooving and undercutting... Waldes Truarc Grooving Tool!

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RETAINING RINGS

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Please send the new supplement No. 1 which brings Truarc Catalog RR 9-52 up to date.
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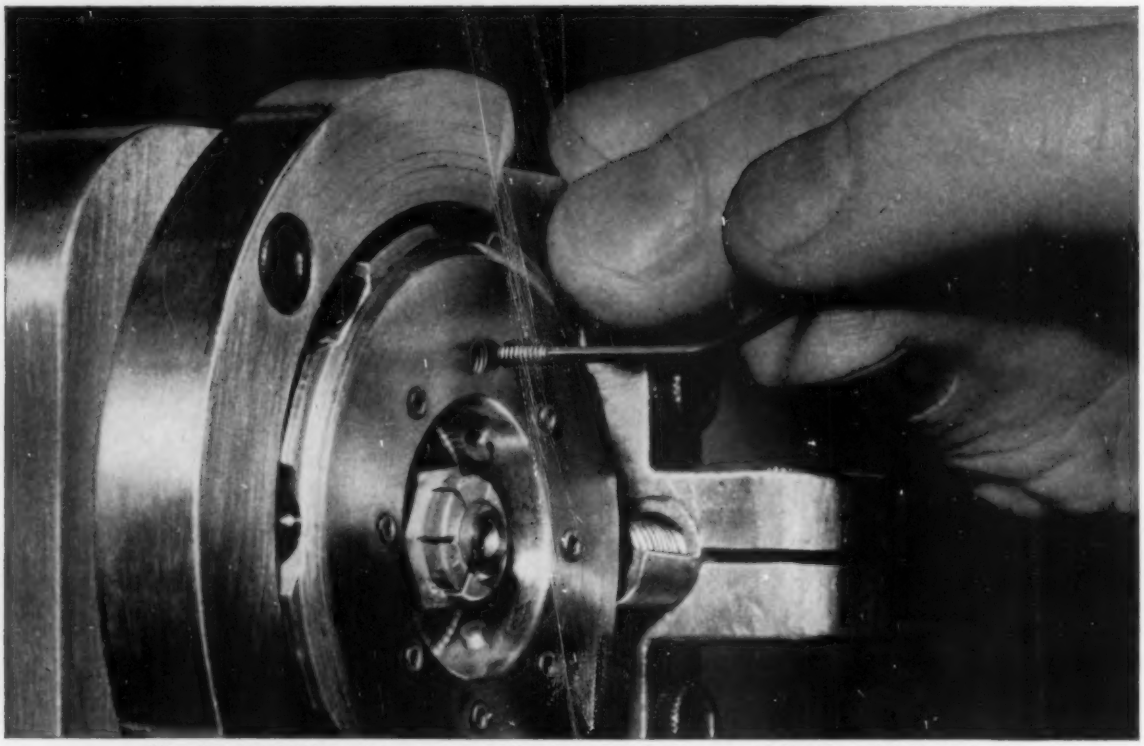
City.....*Zone*.....*State*.....

PN078

WALDES TRUARC Retaining Rings, Grooving Tools, Pliers, Applicators and Dispensers are protected by one or more of the following U. S. Patents: 2,382,948; 2,411,426; 2,411,761; 2,416,852; 2,420,921; 2,428,341; 2,439,785; 2,441,846; 2,455,165; 2,483,379; 2,483,380; 2,483,383; 2,487,802; 2,487,803; 2,491,306; 2,491,310; 2,509,081; 2,544,631; 2,546,616; 2,547,263; 2,558,704; 2,574,034; 2,577,319; 2,595,787, and other U. S. Patents pending. Equal patent protection established in foreign countries.



Microsize UNBRAKO socket screws simplify design problems—even in highly specialized equipment like this prototype precision loading device for use in advanced automated production operations.

Miniaturize with UNBRAKO set screws

HEAT-TREATED ALLOY STEEL*
PLAIN CUP POINT
Class 3 Fit Standard

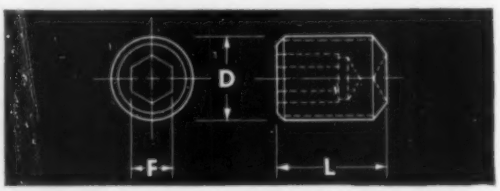
Diameter		Threads per inch NC	Threads per inch NF	L Overall Length	Recommended Installation Torque in Inch-Pounds NC	Recommended Installation Torque in Inch-Pounds NF	Weight per Box of 100 in Pounds
#0	D .060 F .028	..	80	1/16	..	.5	.01
		..	80	3/32	..	.5	.01
		..	80	1/8	..	.5	.01
		..	80	5/32	..	.5	.01
		..	80	3/16	..	.5	.01
		..	80	1/4	..	.5	.01
#1	D .073 F .035	..	72	1/16	..	1.5	.02
		..	72	3/32	..	1.5	.02
		..	72	1/8	..	1.5	.02
		..	72	5/32	..	1.5	.02
		..	72	3/16	..	1.5	.02
		..	72	1/4	..	1.5	.02
#2	D .086 F .035	56	..	1/16	1.5	..	.03
		56	..	3/32	1.5	..	.03
		56	..	1/8	1.5	..	.03
		56	..	5/32	1.5	..	.03
		56	..	3/16	1.5	..	.03
		56	..	1/4	1.5	..	.03
#3	D .099 F .050	48	..	3/32	5.0	..	.04
		48	..	1/8	5.0	..	.04
		48	..	5/32	5.0	..	.04
		48	..	3/16	5.0	..	.04
		48	..	1/4	5.0	..	.04

*Also available in stainless steel

You need not design special set screws to secure your new miniaturized equipment. Microsize UNBRAKOS were developed specifically for use in modern small devices.

UNBRAKO screws are made of carefully selected alloy steel. They are manufactured to timepiece precision. Sockets are deep and uniform for greatest wrench engagement and longest reuse. Threads are fully formed for maximum strength and exact fit. And UNBRAKOS are heat treated to the optimum condition for high tensile strength and ductility without brittleness or decarburization.

Ask your authorized industrial distributor about microsize UNBRAKO socket screws today. Or write us for Bulletin 2055 and samples. Unbrako Socket Screw Division, STANDARD PRESSED STEEL CO., Jenkintown 28, Pa.



STANDARD PRESSED STEEL CO.
UNBRAKO SOCKET SCREW DIVISION
SPS
JENKINTOWN PENNSYLVANIA

Now available... new hollow aluminum bar stock

Harvey Aluminum hollow bar stock is now available for a wide variety of hollow-part machining jobs. The new bar stock offers material savings, speeds production, and drastically cuts chip handling and scrap waste. Made of a special Harvey aluminum alloy, the new bar provides exceptionally high yield strength and corrosion resistance, has excellent machinability and surface finish. For *most* applications, the cost of hollow aluminum bar is 20% to 30% *lower* than conventional solid bar . . . . because the hole is already there!

It will pay you to immediately investigate the wide range of sizes available. Write or call today to have your Harvey field engineer show you how to save time and money with the new hollow aluminum bar stock. *Harvey Aluminum, Torrance, Calif. Branch offices in principal cities.*

Harvey is a leading independent producer of quality aluminum products. Extrusions in all alloys and in all sizes, special shapes, press forgings, hollow sections, structurals, rod and bar, forging stock, pipe, tube, impact extrusions, aluminum screw machine products and related products. Harvey is also producing similar items in titanium and steel.

Making the most of aluminum...

for everyone

HARVEY Aluminum

HARVEY ALUMINUM SALES, INC., TORRANCE, CALIFORNIA • BRANCH OFFICES IN PRINCIPAL CITIES

(Aluminum Company of America photo).

At one stroke this press can forge pieces 10′ wide or 24′ long. It can change a 2,000-pound aluminum slab into a complicated aircraft component... saving material as well as machining and assembly time. Cast and forged nickel alloy steels provide the strength and toughness needed in columns, cylinders, die-block holders and dies of this giant machine. Among the first of the facilities in the U. S. Air Force Heavy Press Program, this unit is a notable engineering achievement of United Engineering & Foundry Co., Pittsburgh, Pa.

Nickel alloy steels strengthen huge press for 35,000-ton squeeze

EIGHT 200,000-POUND FORGINGS of steel fortified with 2¼% nickel! That's what was specified to give this mammoth press essential strength. Used as four 2-column units, these forgings are subjected to the tremendous force of 35,000 tons.

Nickel alloy steel provides the level of strength and notch toughness required. These massive columns are each 61′ high and 34″ in diameter. Whenever a component's size restricts methods of heat-treating, or permits forging only limited portions at a time, improved strength and elastic properties depend particularly upon correct alloy content.

Nickel alloyed steels are used for still other parts that encounter high stresses and loads.

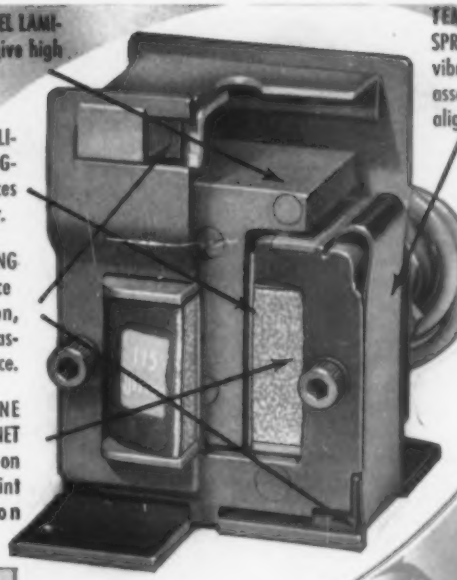
Dies and die holders gain needed stamina from additions of nickel. Among the largest steel castings ever used in press construction, the top and bottom die holders of this press are nickel-chromium-molybdenum steel approximating the 4340 composition. Each measures 26′ by 12′ by 25″ and weighs 350,000 pounds.

In many a metal, you can improve specific properties by use of nickel alone or in combination with other alloy elements. When you seek the solution to a metal problem, let us give you the benefit of our wide practical experience.

Send the details of your difficulty for our suggestions. Write us now.

INCO TRADE MARK **THE INTERNATIONAL NICKEL COMPANY, INC.** 67 Wall Street New York 5, N. Y.

the "inside" story!



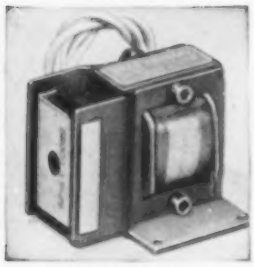
SILICON STEEL LAMINATIONS—give high efficiency.

HARDENED BERYLLIUM COPPER PLUNGER GUIDE — reduces friction and wear.

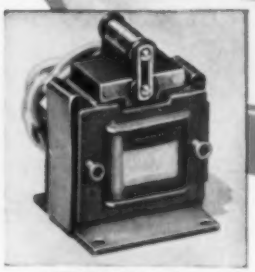
SHOCK-ABSORBING BUMPERS — reduce self-destruction, cushion stroke, assure longer service.

HEAVY SILICONE INSULATED MAGNET WIRE — wound on high flow point molded nylon bobbin.

TEMPERED STEEL SPRING — absorbs vibration — holds assembly firmly in alignment.



HORIZONTAL PUSH-TYPE WELDED BASE



VERTICAL PULL TYPE SHOCK-MOUNTED

VERTICAL PUSH-TYPE WELDED BASE

AC WAFER SOLENOID

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In addition to all the "inside" advantages, Decco Solenoids are compactly designed and thoroughly impregnated with silicone baking varnish for high moisture resistance.

Decco Solenoids are made in all types, sizes and shapes. SPECIAL SOLENOIDS ENGINEERED TO YOUR PROBLEMS.

Decco SOLENOIDS THE HEART OF DEPENDABLE AUTOMATION EQUIPMENT

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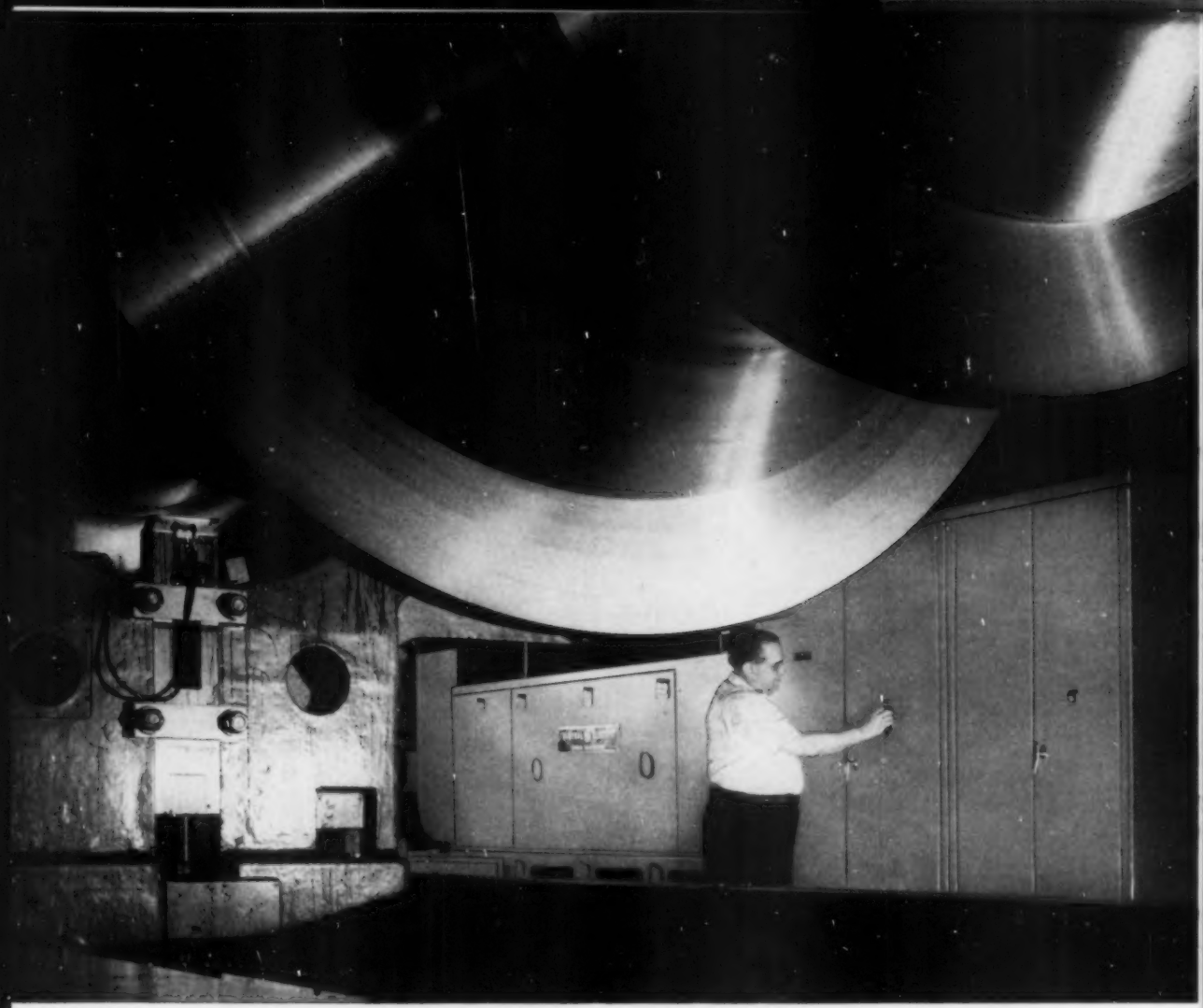
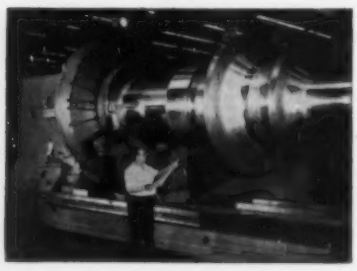


Power and Precision—in a Package

General Electric D-c Drives Supply Power and Close Control for New Lathe

Machining 200-ton workpieces at closely regulated speeds over a wide range demands precise control. To obtain it this giant lathe relies on d-c power supplied by General Electric Speed Variators.

Combining Power and Precision, it can handle jobs 55 feet long, 12 feet in diameter and weighing 200 tons. It is one of the heaviest and most powerful lathes ever built in America.



Versatile D-c Power is obtained from the compact Speed Variator power unit installed near the lathe. Containing the motor-generator set and controls in a single cabinet line-up, the power unit supplies direct current for the 200-hp drive motor.

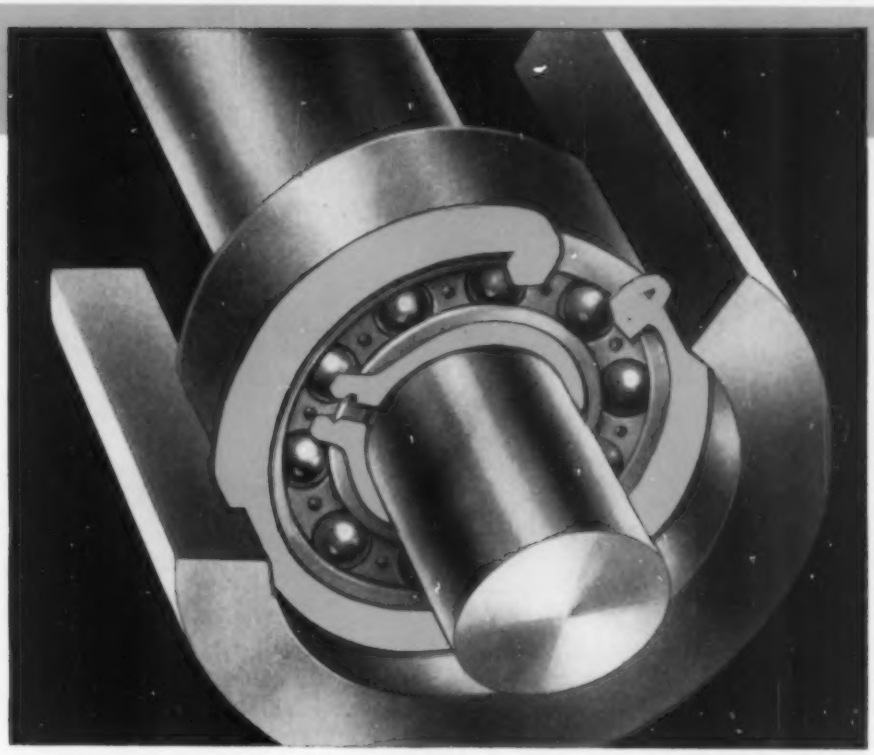
Finger Tip Control, permitting the operator to easily set and hold rotating speeds, is provided by a conveniently mounted push-button station. The accurate control of the speed assures mirror-like surface finishes. The wide choice of speeds provides the flexibility for handling workpieces of varying diameter.

Controlling Heavy or Light Loads with precision and accuracy is characteristic of General Electric Packaged Speed Variators. Providing stepless, motor speed control over wide ranges, these drives are tailored to your particular application by General Electric engineers.

A General Electric Sales Engineer would like to help build this precision into your machines. Why not ask him to call? *Direct Current Motor and Generator Department, General Electric Company, Erie, Pennsylvania.* 821-4

GENERAL ELECTRIC

• Save Time • Save Materials • Save Money!



Examine the designs of all your products and machines. No doubt you can use retaining rings on axles and in housings—not **only to save assembly time, but to save weight, parts and space.**

The use of these inexpensive yet efficient artificial shoulders is already widespread, and is increasing daily.

There are literally thousands of places in which redesigning for retaining rings can increase your profits and improve your products—uses ranging from heavy duty engines and drill presses to toys, gadgets and small parts of innumerable articles.

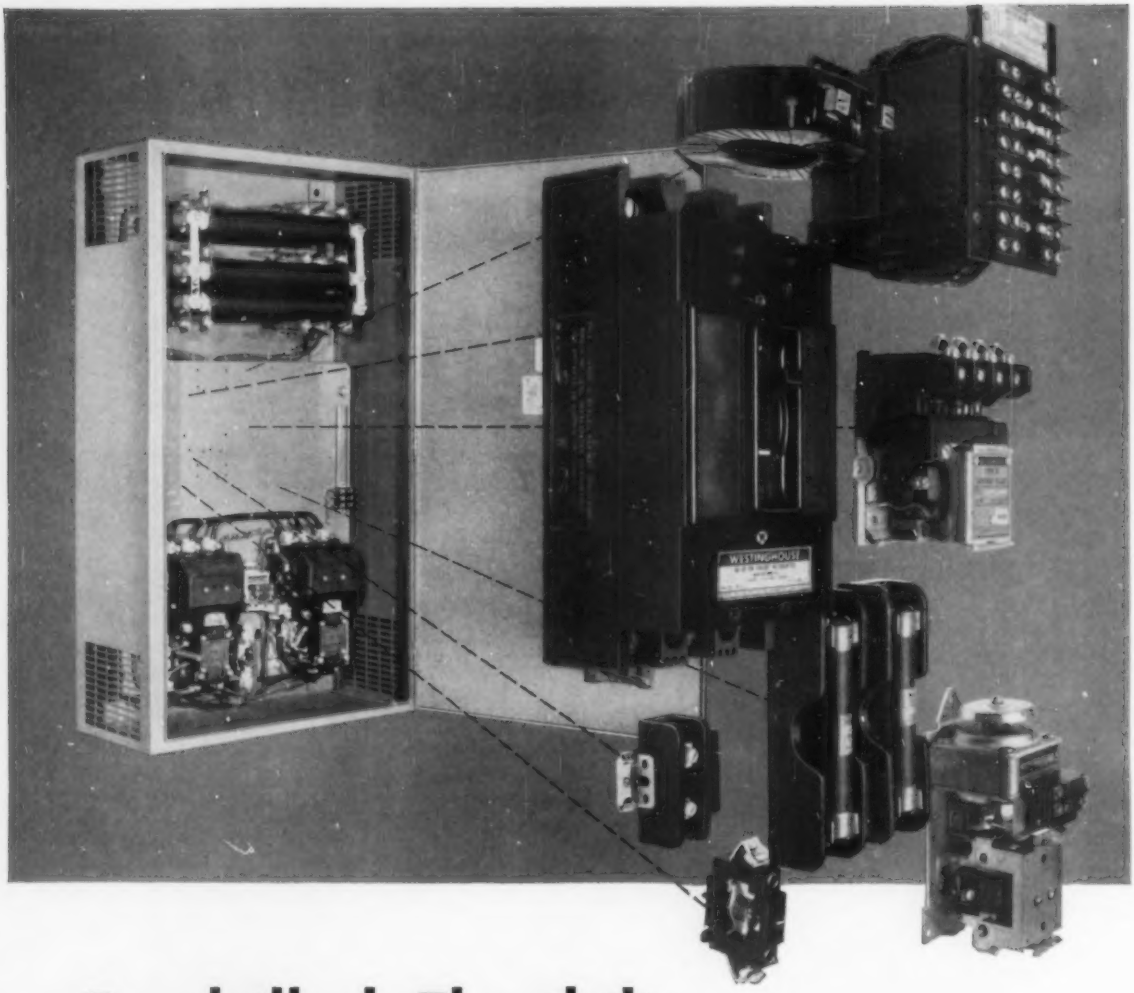
It's wasteful to cut down shafts to make shoulders. Redesign to groove smaller shafts and housings and use these high grade steel rings.

Let our engineers consult with you. Send for folders.

Don't pass up this opportunity to increase profits.

THE NATIONAL LOCK WASHER CO.

NEWARK 5, NEW JERSEY • MILWAUKEE 2, WISCONSIN



Predrilled Flexibility

The Westinghouse Reduced-Voltage Starter

Room to grow is built right in at the factory with the Westinghouse Add-A-Part panel. When additions to systems require such modifications as control circuit fuses, auxiliary relays, or current transformers, the space for them is there—engineered right into industry's most advanced reduced-voltage starter.

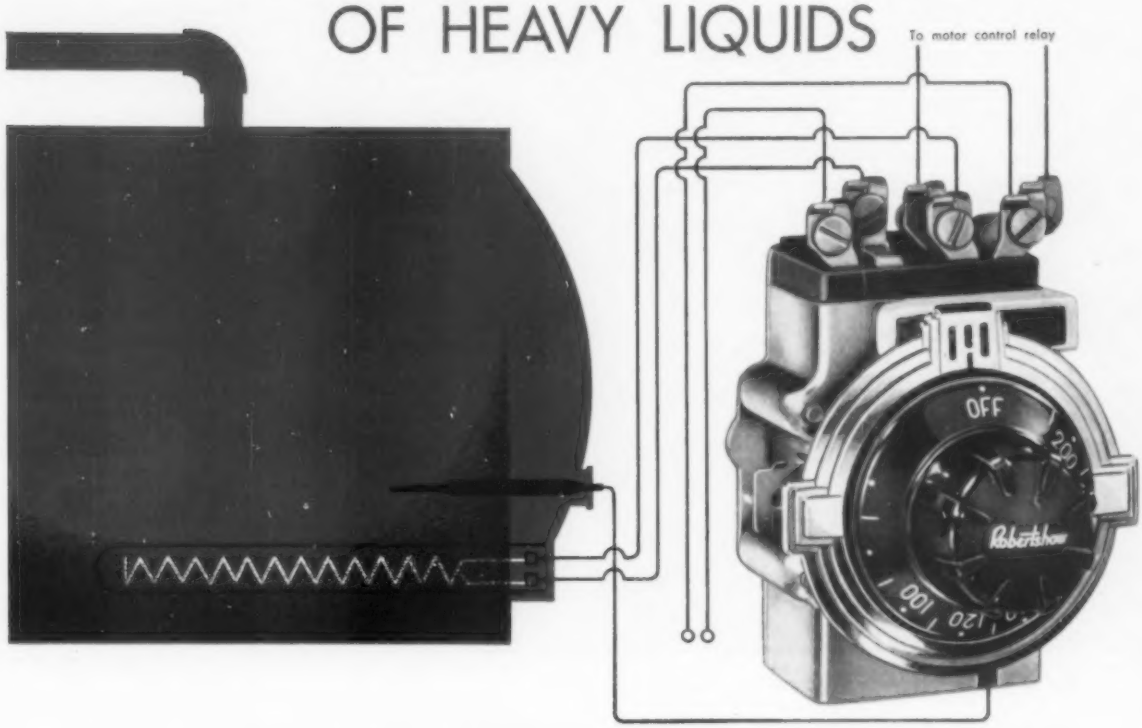
Other features that make this starter the most flexible, available today include pneumatic types AM and AMB relays for easy, stepless timing adjustment—adjustable resistor taps so you can adjust starting voltages to meet your requirements.

For all the facts, call your Westinghouse sales engineer. Ask for DB 11-500. You'll see one more reason why you can be sure . . . if it's Westinghouse. J-21930

WATCH WESTINGHOUSE!

WHERE BIG THINGS ARE HAPPENING TODAY!

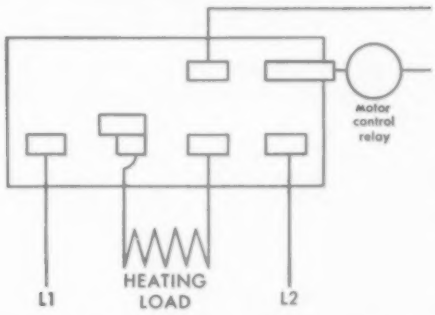
FOR TEMPERATURE AND MOVEMENT CONTROL OF HEAVY LIQUIDS



New double circuit control with thermal delay action

The new F2 is designed especially for the control and movement of heavy liquids where liquid flow or agitation must begin before the liquid temperature reaches the point for maximum ease of liquid movement.

With pumping of heavy fuel oil for example, pumping can be set to begin at 130° while the temperature of the oil continues to rise to 180° for maximum ease in pumping. The F2 controls both temperature and pump or agitator cycle.



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Robertshaw-Fulton Controls Company
Youngwood, Pennsylvania

Please send more information on your F2 ☐
Also send information on a control for following application: _____

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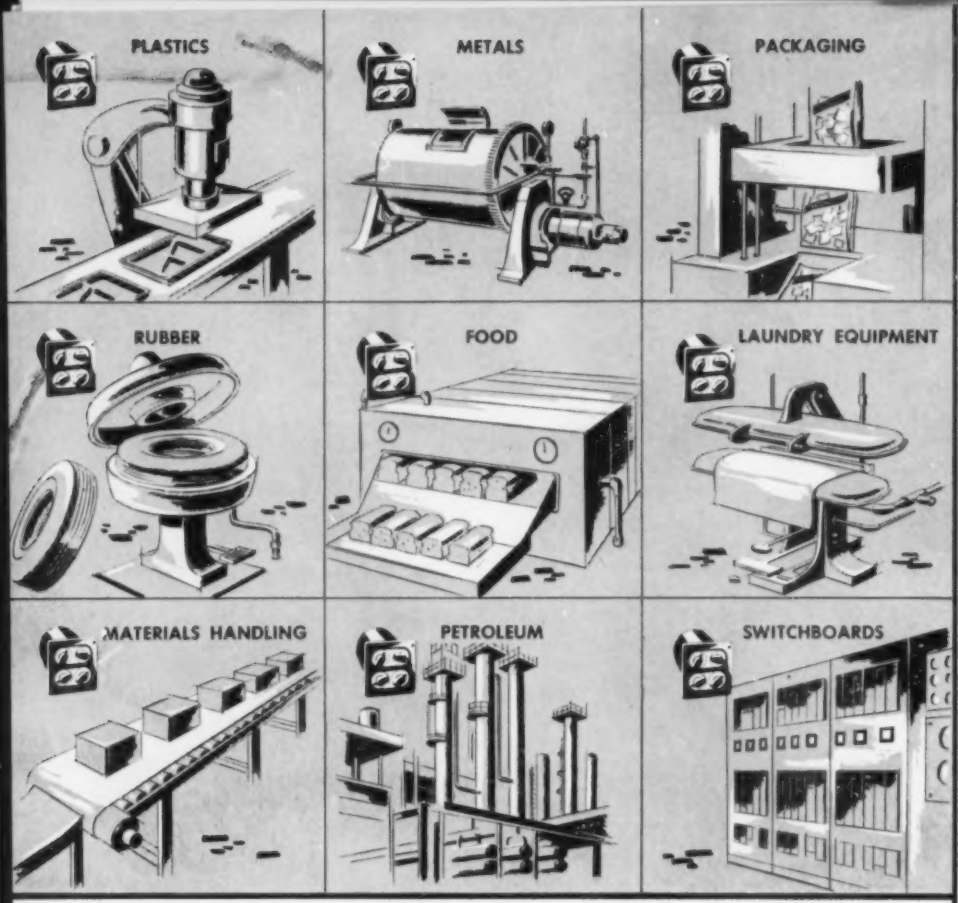
CITY _____ **ZONE** ____ **STATE** _____

BY _____

TITLE _____



In All These Applications . . .

3 NEW FEATURES OF G-E INTERVAL TIMER IMPROVE CONTROL AND CUT TIMING COSTS

To give you even greater versatility in time control, the General Electric TSA-18 interval timer may now be equipped with these optional features: new reset contacts, elapsed time indication and a program retaining mechanism.

NEW RESET CONTACTS make possible *either* automatic resetting or automatic recycling in the same timer. A simple change in external wiring is all that is necessary to change from one to the other. With *automatic resetting* you can eliminate manual resetting or mortgaging another circuit to achieve the reset action. With *automatic recycling*, the timer will reset at the end of a time cycle and immediately start the next cycle. This gives you a continuous repeating time-cycle program.

ELAPSED-TIME INDICATION, shown by a small dial on the timer face, gives you a continuous, accurate reading of time elapsed from the start of your time-cycle program—especially useful on long programs.

PROGRAM RETAINING: In case of power failure the program-retaining mechanism will hold the timer at the point of interruption and restart it at this point when power is restored. (Cannot be used in the same timer with reset contacts.)

MANY STANDARD "EXTRAS" are included in the TSA-18 timer: delayed on-and-off timing in intervals from 1 second to 30 hours; knob-locking device to prevent missetting; high setting accuracy of 1%; high repeat accuracy of ¼%; dust-proof case—*all standard at no extra cost.*

YOUR COSTS ARE REDUCED because the TSA-18 interval timer will increase the equipment operators can handle and free them for more productive activity. Waste or spoilage of materials can also be reduced, with the higher degree of uniformity that G-E timed control gives you.

For further information, contact your nearest General Electric Apparatus Sales Office, or write for bulletin GEC-1223 to Section 584-3, General Electric Company, Schenectady 5, N. Y.

Progress Is Our Most Important Product

GENERAL ELECTRIC

G-E TSA-18 TIMER WILL REDUCE COSTS IN ALL THESE OPERATIONS

IN PLASTICS

Automatic molding
Scheduled mixing of material
Batch weighing

IN METALS

Heat treating
Flame hardening
Induction heater annealing
Quenching cycles
Firing of regenerative furnaces
Plating
Bath and soak cycles
Motor reversing cycles—tumbling
Batch weighing
Sequencial adding of materials

IN FOOD PROCESSING

Sugar centrifuge control
Dough mixing
Dehydration equipment
Automatic chicken pickers
Roasting processes
Motor reversing cycles—agitators
Adding ingredients in sequence
Infra-red oven control
Molding and pressing
Batch weighing
Bag folders
Heat sealers—plastic bags
Bag and box fillers

IN MACHINE TOOLS

Flame hardening
Heat treating
Resurfacing of grinding wheels
Final polishing intervals
Periodic lubrication

IN RUBBER

Tire and tube curing cycles
Injection period control

IN CHEMICALS

Motor reversing cycles—agitators
Atomic radiation control—setting exposure reading interval
Batch weighing
Sequencial adding of materials
Testing photographic emulsions
Infra-red oven control
Purging of filtration tanks
Dehydration equipment

IN CONTROL PANELS

Single time-interval operation
Multiple time-interval operation
Recycling of timed operations
Sequencial cycling of automatic machines
Motor-reversing cycles
Reclosing of circuit breakers
Unattended substation starting

AND MANY OTHERS

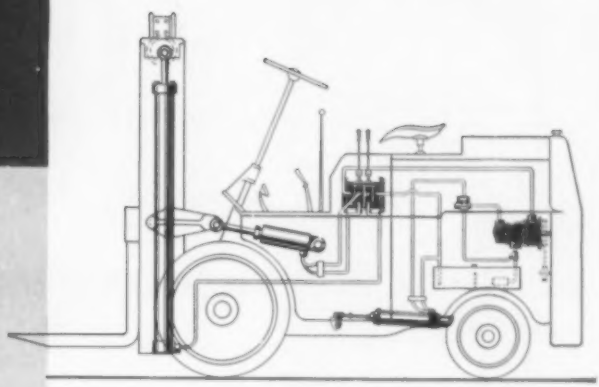
Transit-system scheduling
Glass polishing cycles
Spin and surge protection of deep well pumps
Automatic paint spraying devices
Photo copying equipment
Automatic door closing
Dry cleaning and laundry machines
Alarm initiation
Dust collectors and shakers
Quality control
Materials handling
Periodic test sampling

VICKERS

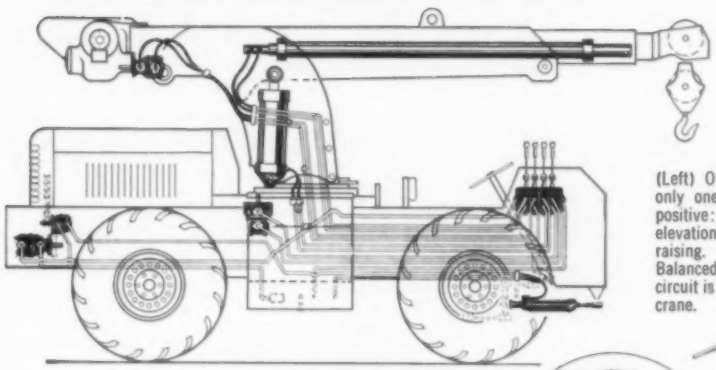
HYDRAULIC SYSTEMS

Designate Superior Materials Handling Equipment

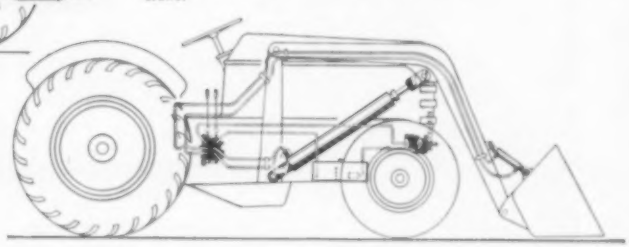
"Nobody sets a diamond in a brass ring." And when a manufacturer of materials handling equipment uses Vickers Hydraulics, it is indicative of superior quality throughout. To the inherent advantages of hydraulic control, Vickers adds the benefits of a nation-wide and full time field engineering and service organization of unequaled experience. Vickers has the complete line of hydraulic equipment necessary to take undivided system responsibility . . . to eliminate any risk of incompatibility of hydraulic components. For further information, ask for new Bulletin M5101A.



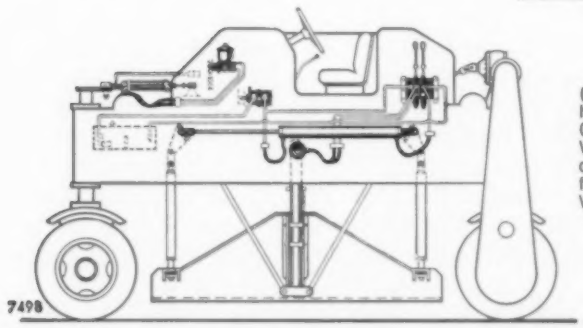
(Above) Fast tilting and lifting are possible along with exclusive "feathering" ability. Also, fingertip power steering permits operator to maneuver vehicle with one hand and control loading operations with the other. Additional vehicle attachments can be hydraulically controlled by simply adding sections to existing control valve eliminating necessity of mounting separate valves.



(Left) One Vickers Hydraulic System (using only one pump) provides fast, smooth and positive: (1) turntable rotation, (2) boom elevation, (3) boom extension, and (4) load raising. Turntable is driven by a Vickers Balanced Vane Type Fluid Motor. Another circuit is used for power steering this hydraulic crane.



(Right) Fast, easy and dependable operation of front end loader depends upon Vickers Balanced Vane Pump and Vickers Two-Section Directional Control Valve. Automatic wear compensation is inherent in all Vickers Balanced Vane Type Pumps. Note simplicity of installation.



7498

(Left) Straddle carrier uses hydraulic power to handle the load with precision and speed. Compact, two-section Vickers Multiple Unit Valve has double-acting valve for opening and closing load hooks and single-acting section for raising load. Separate circuit provides Vickers Hydraulic Power Steering.

WRITE FOR BULLETIN M5101A

VICKERS INCORPORATED

DIVISION OF SPERRY RAND CORPORATION

ADMINISTRATIVE and ENGINEERING CENTER

Department 1454 • Detroit 32, Michigan

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IN CANADA: Vickers-Sperry of Canada, Ltd., Toronto

ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921

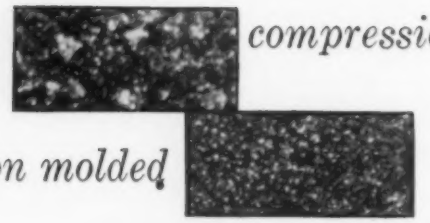
problem:

who makes longer-lasting rubber O-rings of ±.002″ tolerance at low cost?

answer:

minnesota rubber and gasket company

evidence:



compression molded

injection molded

Minnesota Rubber O-rings are *injection molded* by the exclusive Minnesota Rubber process. Result is increased resistance to abrasions and chemical actions due to consistent, unequalled high density. Evidence of the greater density of injection molding is shown here in cross sections of Standard Buna N compound, .026″x.019″, magnified 240 diameters by University of Minnesota.

In addition, Minnesota Rubber's O-rings have no flash. Tolerances can be kept within ±.002 inch. Cost? M.R. O-rings cost as little as ordinary O-rings! And M.R.'s 100% inspection and quality control saves you additional money in replacement costs, too.

free samples and data:

Free samples of Minnesota Rubber O-rings are available together with technical information and installation data.

minnesota rubber and gasket company

Originators of modern rubber injection molding
Dept. 204, 3630 Wooddale Ave., Minneapolis, Minn., Phone: WEst 9-6781

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Send for your free trial sheet today. Discover for yourself the big difference, except in price, that has gained "Kovel" acceptance as the finest general purpose tracing paper of its type on the market.

For all the advantages of "Kovel" in a thinner, untinted white paper, try No. 354 "Frenchvel" Tracing Paper. The high translucency of "Frenchvel" makes it ideal for tracing from weak-lined drawings or blueprints and for higher volume reproduction.

And for a Wonderful Difference in a Smooth Surface Paper, try . . .

BRUNING'S No. 350 "VELLUX"

The moment you put pencil, or ink, to this smooth-surface, vellum-type tracing paper, you'll see what a difference quality can make. This permanently white, transparentized paper is unsurpassed for textural uniformity and for fine all-around performance. Prove the difference to yourself by sending today for your free trial sheet.

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HOW JOHNSON* MAKES A BETTER OUTBOARD MOTOR WITH ALCOA SCREW MACHINE STOCK

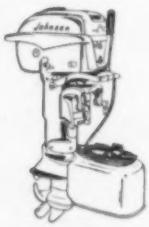
The outboard motor of 1921 was a heavy iron and brass thing that literally shook a boat to pieces. In that year, Johnson Motors and Alcoa changed the whole picture. The first Johnson Waterbug combined astounding lightness (35 pounds) with unheard-of power (2 hp) in a radical twin cylinder design. In three years, Johnson was the largest outboard manufacturer in the business.

Today, Johnson is still the largest. Its use of Alcoa® Aluminum Screw Machine Stock makes interesting reading to any manufacturer wanting to improve his product and make it sell faster.

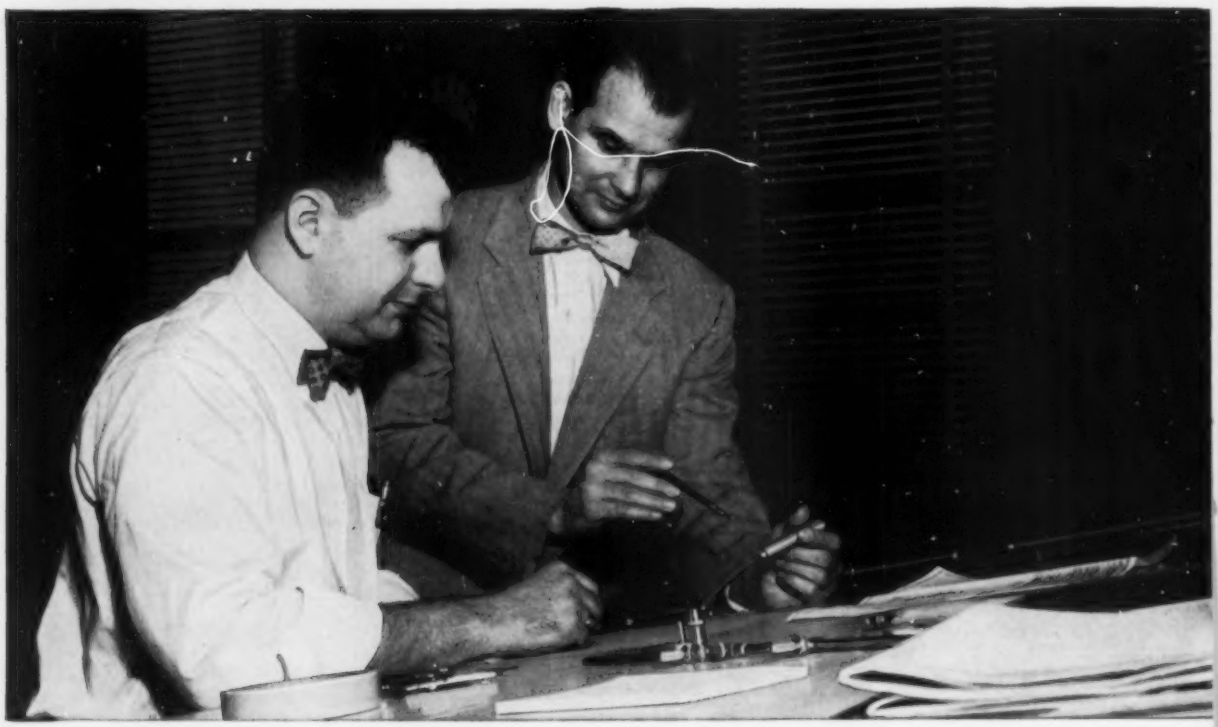
Few products demand so much from machined parts as outboard motors—lightness, strength and corrosion resistance, too. These three advantages often set aluminum head and shoulders above other materials for screw machine parts. But consider the other advantages of aluminum which may have a more important place in your product. Exceptional machinability—limited almost entirely by machine capacity; high electrical and thermal conductivity; ease of finishing. These performance characteristics of Alcoa Screw Machine Stock, when coupled with the solid economic fact that you get three times as many parts per pound as with heavy metals, make up the total good sense of aluminum.

These are hard, commercial reasons why aluminum more than ever before should be carefully considered for every screw machine part you make or buy. Help in this type of analysis is available from every one of Alcoa's local sales offices listed in your phone book under "Aluminum." Aluminum Company of America, 865-G Alcoa Building, Pittsburgh 19, Pennsylvania.

*Johnson
MOTORS
Waukegan, Illinois



Chief Engineer, S. A. Metcalf (at right);
Ed Stoyonoff, Senior Draftsman (at left).



IN PURCHASING

Purchasing Agent, J. G. Kohler, says—"We have always used Alcoa Aluminum Screw Machine Stock and today we buy 100% of our requirements from Alcoa. We have never had a reject to my knowledge. It is this dependability of service, coupled with Alcoa technical help and Alcoa technical booklets, that keeps Alcoa strongly in our supply picture. Being the world's largest maker of outboard motors, we must schedule our buying closely to production. We know we can depend on Alcoa."

Purchasing Agent, J. G. Kohler.

IN PRODUCTION

Foreman of Automatic Screw Machine department, F. H. Mitchell, says—"We run aluminum at the top capacity of our machines. Tolerances are often as close as two-tenths. Aluminum machines so easily that we often reduce the O. D. of a part with die chasers. We also find that the cutoff finish we get with aluminum is superior to brass and steel. Tool life is fine. Tool preparation for aluminum is easy. We use Alcoa booklets as standard reference material and aluminum gives us no headaches in production. We like it."

Foreman, F. H. Mitchell (at right);
James Hairrell, Machine Operator (at left).

IN DESIGN

Chief Engineer, S. L. Metcalf, says—"Our prime design consideration at Johnson is putting the most power possible in every pound of motor. For this reason we naturally rely on aluminum for over 50 screw machine parts. In addition, we have severe corrosion requirements—another reason for our use of aluminum. The fact that we get three times as many parts per pound with aluminum as with heavy metals also helps us make a better motor at lower cost. Alcoa technical help is always at our disposal. Because we use so much aluminum on our motors, we frequently have threaded aluminum parts mated with other aluminum parts. In these cases, the ease of anodizing aluminum nicely avoids any possible problems of seizure and salt water corrosion."

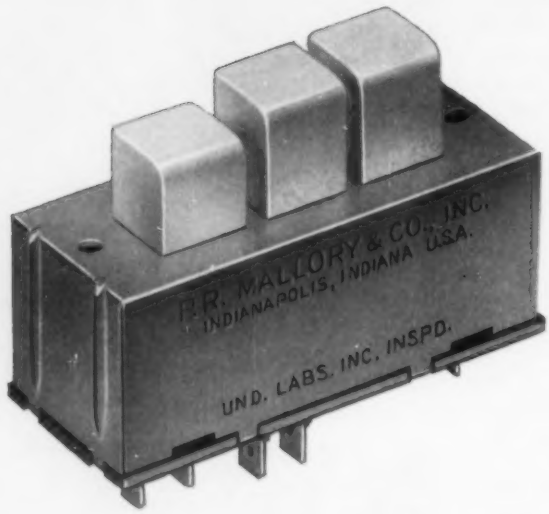
Typical parts made of Alcoa Aluminum
Screw Machine Stock by Johnson Motors.

THE ALCOA HOUR
TELEVISION'S FINEST LIVE DRAMA
ALTERNATE SUNDAY EVENINGS

Your Guide to the Best in Aluminum Value

ALCOA ALUMINUM
SCREW MACHINE STOCK
ALCOA

MALLORY



Ideal for many medium-power appliances, this Mallory push-button switch can provide 24 different switching sequences, on circuits up to 15 amperes, 125 V, or 7½ amperes, 250 V.

How Mallory-Engineered Switches Add New Values to Your Product

THE PUSH-BUTTON SWITCH shown above is typical of the hundreds of designs that Mallory manufactures for use in leading appliances and industrial products. If you manufacture air conditioners, ironers, refrigerators, fans or similar products, you may find that this particular model is exactly what you need.

Regardless of what your particular requirements may be, you can profit by bringing your switch problems to Mallory, for extra values—

In engineering. Mallory switch specialists have worked for years in cooperation with major manufacturers . . . have built up a storehouse of experience in solving switch problems of many types.

In economy. Mallory switches are made to precise standards in modern, high volume production facilities. Standard models include some twenty basic types, each with numerous modifications to offer you a wide range of switching functions at economical cost. For special requirements, custom-engineered switches are produced efficiently and on prompt delivery schedules.

In performance. The quality built into Mallory switches, through expert design and precision manufacturing, has made them the standard of performance in the industry. They can be relied upon for service life well beyond usual equipment specifications.

Mallory switch engineers will be glad to consult on your specific application. For full facts, write or call Mallory today.

Expect more . . . get more from

Serving Industry with These Products:

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P. R. MALLORY & CO. Inc.
MALLORY
P. R. MALLORY & CO., Inc., INDIANAPOLIS 6, INDIANA

Enjay Butyl—*today's fabulous rubber*
gives new life to backyard wading pools

Enjay Butyl brings long life and performance strength to the sensational new Bil-O-Matic®, rubberized fabric wading pool manufactured by the Bilnor Corporation. With its resistance to aging, sunlight, tear and impact damage, the pool manufactured with Enjay Butyl gives outstanding performance. Unlike other pools that cracked and leaked after exposure to sunlight, these *new* pools retain their durability under even the toughest conditions of wear, stress, and weather. The Enjay Butyl label on the carton assures the customer of exceptional quality.

Extremely versatile, Enjay Butyl has led to improved product performance in a wide variety of fields. This amazing, low-cost rubber is *immediately available* in non-staining grades for white and light-colored applications. To find out where Enjay Butyl can *cut costs* and *improve your product*, contact the Enjay Company. Complete laboratory facilities, fully staffed by trained technicians, are at your service.

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Pioneer in Petrochemicals

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ENJAY BUTYL

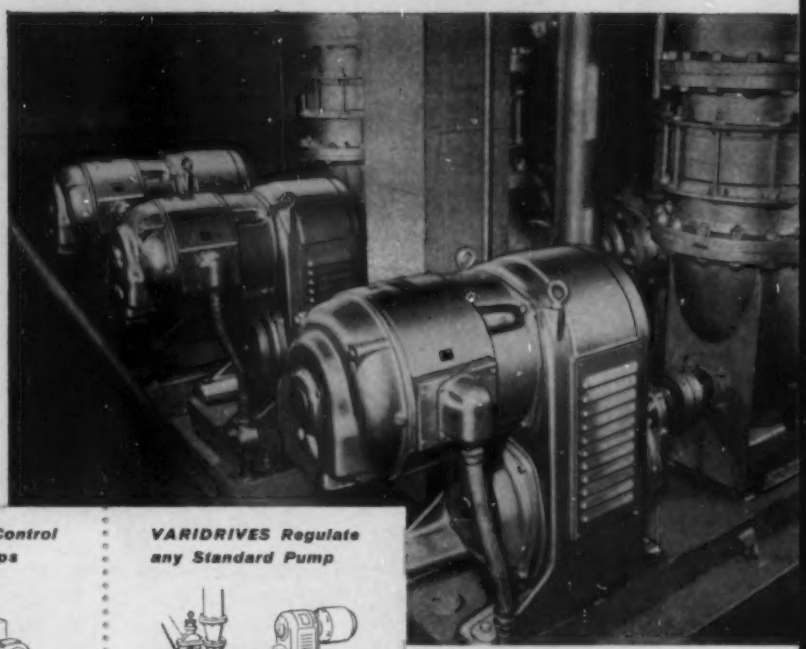
Enjay Butyl is the super-durable rubber with *outstanding* resistance to aging • abrasion • tear • chipping • cracking • ozone and corona • chemicals • gases • heat • cold • sunlight • moisture.

VARIABLE SPEEDS FOR VARYING NEEDS

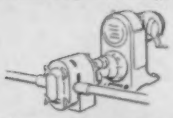
Control Pumping with U.S. VARIDRIVES

Regulating the High and Low of Sewage Flow with U.S. VARIDRIVES

Thirty-two 20 h.p. U. S. Varidrive motors like these shown increase or decrease necessary pumping action of axial flow pumps which transfer sewage at the new Hyperion Sewage Disposal Plant of the City of Los Angeles. This is another example of the versatility of U.S. Varidrive motors to handle variable speed pumping problems in all types of industry. Varidrives are available from ¼ to 60 h.p. Speeds 2 to 10,000 rpm.

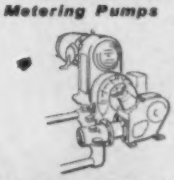


VARIDRIVES Power Pumps used for Pumping Beverages



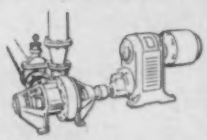
High pressure, low volume rotary positive displacement pumps used in food plants have a variety of uses with the help of variable speed.

VARIDRIVES Control Metering Pumps



Piston type, positive displacement pumps used for proportioning or metering liquids are often regulated by Varidrives.

VARIDRIVES Regulate any Standard Pump



Centrifugal pumps are made more versatile in handling many different pumping conditions with variable-speed drives.

Versatile VARIDRIVE for Additional Applications

- CONVEYORS
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- MIXING & BLENDING
- CANNING
- GRINDING
- VENTILATION
- BUFFING

U.S. Electrical MOTORS

MOTORS

PEN-7

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MAIL COUPON NOW

(Advertisement)

Riveting With a Hammer in Blind or Open Applications

Elimination of special riveting tools can mean faster production, lower costs, no down time.

J. K. BARRY, M. E.

The use of blind rivets installed with only an ordinary hammer from one side of the job offers a highly simplified method of fastening. Speed, convenience and *low installed cost* make Drive Riveting preferable not only for blind joints, but for fastening many parts that can be reached from either side.

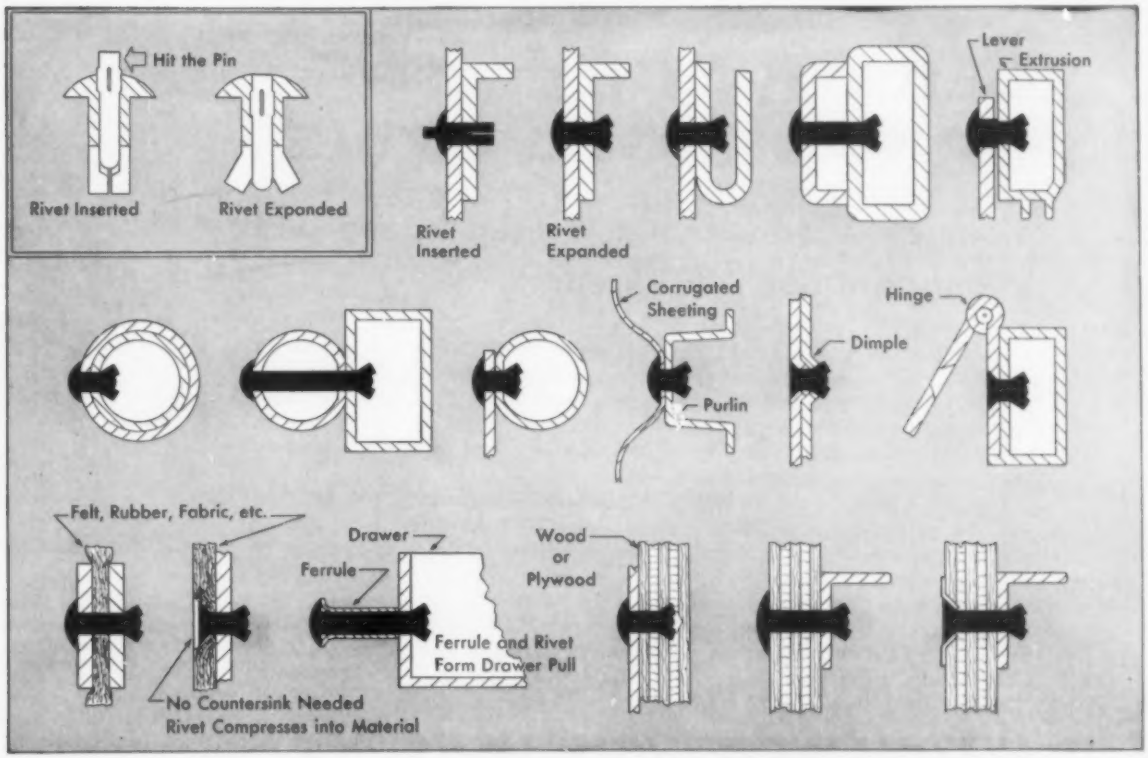
The Southco Drive Rivet has a cored, slotted body with a grooved pin protruding from its head. When the rivet is inserted through parts to be fastened, the pin is driven flush with the rivet head causing the expanding prongs to form a blind head behind the rear sheet. No further finishing is necessary, since the pin seats itself permanently to complete the smooth head contour.

Drive Riveting has five major advantages:

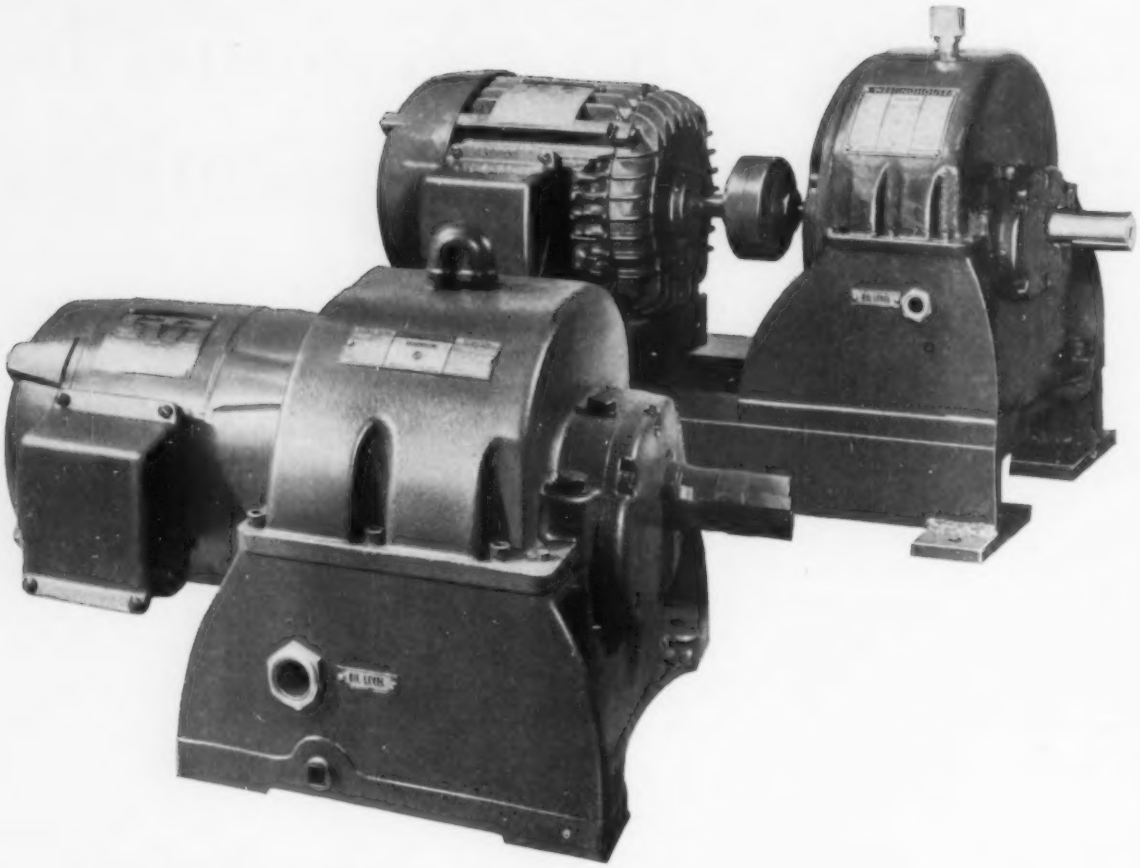
1. No investment in special tooling.
2. No lost time for tool repairs.
3. No limitation on the number of men who can install rivets.
4. Speed comparable to nailing.
5. Only one man is needed.

Widely used in truck bodies, storm doors, metal buildings and hundreds of other industrial applications, Southco Drive Rivets make a secure, vibration-proof joint. A wide range of head styles, diameters and grip lengths is available.

RECOMMENDED APPLICATIONS FOR DRIVE RIVETING



SOUTHCO Division, South Chester Corporation, 236 Industrial Hwy., Lester, Pa.



GEARMOTOR OR PACKAGED DRIVE?

Your selection has a longer future with Westinghouse BPT gearing

Westinghouse gearmotors and DB packaged drives offer important advantages to simplify drive problems and provide long-range dependability.

First, you'll find both lines of gearing readily available. They provide a wide selection in horsepower, speed ratios, direction of power take-off, mounting and coupling methods. This sort of flexibility is bound to save you time in answering space and load problems.

Second, Westinghouse BPT gearing, in both lines, assures a long-range solution to any drive problem. The exclusive BPT heat-treatment process produces unmatched, long wearing, shock-resistant qualities as a result of taper hardening each gear tooth. Heavy-duty, antifriction bearings also insure continued high efficiency under changing load demands.

Get all the facts on Westinghouse gearmotors and DB packaged drives today from your local Westinghouse salesman; or write Westinghouse Electric Corporation, 3 Gateway Center, P. O. Box 868, Pittsburgh 30, Pennsylvania.

J-07351

Exclusive BPT heat-treatment produces a taper hardness from surface to core of each gear tooth for toughness and hardness.

WATCH WESTINGHOUSE!

*WHERE **BIG** THINGS ARE HAPPENING **TODAY!***

DOW CORNING CORPORATION

Silicone News

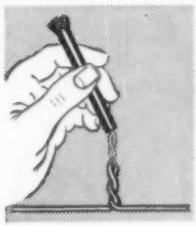
FOR DESIGN ENGINEERS No. 28

Waterproof Wire Splice With Silicone Compound

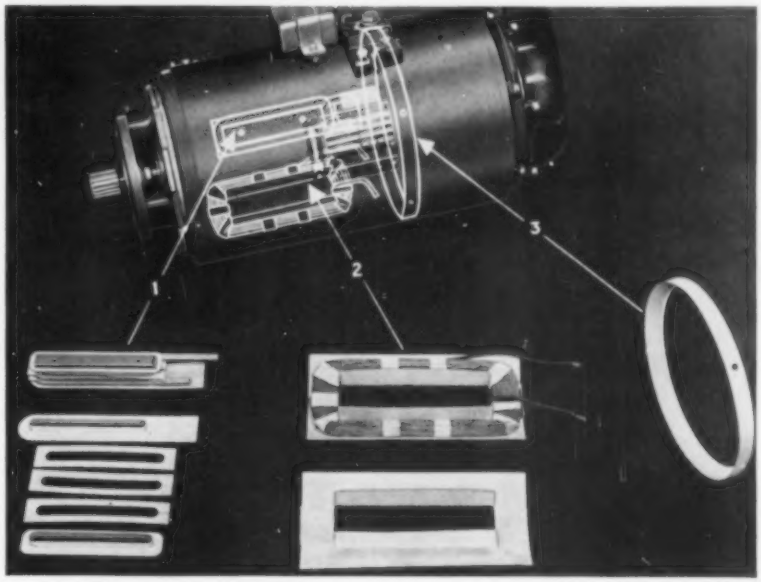
The sales success of "Super-Splice", designed by Superior Cable Corporation, Hickory, N. C., testifies to the superior dielectric properties of Dow Corning Silicone Compound. Over 2,000,000 of the splices have been sold in the last two years.

Originally developed for telephone cable work, the "Super-Splice" is a simple polyethylene sleeve sealed at one end and filled with grease-like Dow Corning silicone compound. It is quickly and easily slipped over twisted pigtails to form a splice that retains optimum electrical insulating properties despite prolonged exposure to moisture.

Extensive laboratory tests have proved that "Super-Splice" retains its full insulating effectiveness even after a full year under water. During these tests, splices featuring polyethylene-insulated wire protected with silicone-filled "Super-Splice" withstood 45,000 volts dc and measured 200,000 megohms insulation resistance while immersed in water.



Since the silicone compound does not harden with aging, the insulator may be removed at any time to facilitate maintenance. "Super-Splices" now available are 2⅛" long and are suitable for straight, butt or bridge splices of 19, 22 or 24 gauge wire. *No. 279*



Silicone-glass components: 1. interpole insulator; 2. shunt field coil insulator; 3. insulator ring.

Bendix Reduces Size And Weight Of Turbojet Generators With Silicone-Glass Laminates

By utilizing the superior thermal stability and dielectric strength of silicone-glass laminates, Red Bank Division of Bendix Aviation Corporation has designed new compactness and efficiency into a generator that meets the rugged requirements of turbojet operation.

This Type 30E10-1 Generator, a 30-volt 400 amp unit, is 6½ inches in diameter and weighs only 67 pounds. Developed to operate at speeds as high as 8000 rpm and for air-blast cooling at altitudes up to 65,000 feet, it features light weight insulating components formed of 2-ply silicone-glass cloth fabricated by Stevens Products, East Orange, N. J. *(cont'd pg. 2)*

New Silicone Based Paint Signals Danger Temperature

Through ingenious use of heat stable Dow Corning silicone resins, Tempil Corporation, New York City, has developed a paint that provides a visual alarm when surfaces are getting too hot for safety. The new paint, "Temp-Alarm ° GA-1", changes color from yellow to maroon at temperatures from 375 to 400 F.

Currently, this new silicone based coating is used on the exteriors of mixing tanks in steel mills. By changing color at the danger temperature, it warns when the tank's fire brick lining is wearing thin.

Since temperatures involved are relatively low so far as the silicone vehicle is concerned, Tempil has been able to concentrate on the proper pigments for desired color sensitivity without fear of paint failure. Even after prolonged exposure to temperatures just below the "danger" range, the paint retains its original dependability. *No. 280*

CLASS H MOTOR STILL ON TEST AFTER 57,417 HOURS AT 240 C

At 10 A.M., June 6, 1946, a Class H insulated 5 hp motor was generator loaded to operate at its test temperature of 240 C in Dow Corning's motor test labs. Every 500 hours since it has been shut down and exposed to 100% relative humidity for 24 hours. As of 11 A. M. June 1, 1956, this motor was still on test after 57,417 hours at an average copper temperature of 240 C! That's equivalent to 349 years operation at the Class H temperature of 180 C.

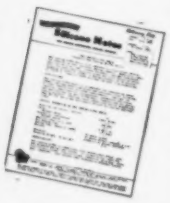
FOR DATA RELATING TO THESE ARTICLES, CIRCLE REFERENCE NUMBER IN COUPON ON NEXT PAGE

MORE

DOW CORNING CORPORATION

Silicone News

DOW CORNING PUBLICATIONS ON NEW DEVELOPMENTS AND TECHNICAL DATA . . . .



"What's a Silicone?" is the title of a 32-page booklet which answers that often asked question in semi-technical terms. Indexed and illustrated, this booklet has earned an international reputation as the most interesting and informative description of silicones ever published. *No. 284*

Lightweight electrical and electronic parts with excellent heat and moisture resistance, high mechanical strength and good dielectric properties can be produced with Dow Corning 301 Molding Compound. Heat distortion temperature of molded parts is greater than 900 F; flexural strength is 12,000 psi. *No. 285*

Silastic, the Dow Corning silicone rubber, keeps its shape, stays resilient from —100 to 500 F; resists hot oils and chemicals; withstands weathering ozone and corona; and is an ideal dielectric material. Properties of Silastic are fully detailed in new reference brochure. *No. 286*

Illustrated brochure presents factual evidence that Dow Corning 41 Silicone Grease cuts relubrication schedules and replacement costs in a wide variety of high temperature, low speed applications. Includes several illustrated and documented case histories describing effectiveness of 41 Grease in oven conveyor bearings, dolly wheels, injection valves and turbine governors. *No. 287*

New booklet on Silicone Based Paints describes and illustrates how these heat, moisture, weather and oxidation resistant coatings improve product finishing and reduce maintenance costs on equipment ranging from industrial furnaces and exhaust stacks to domestic space heaters and garbage incinerators. Also explains difference between the straight silicone and modified silicone paints now available from more than 50 formulators listed as sources of supply. *No. 288*

Now available—1956 Reference Guide to Dow Corning Silicone Products. A concise, comprehensive, 12-page reference that is convenient-to-use. It's packed with data, properties, and information on how you can use silicones in designing new equipment, improving performance and reliability of original equipment, or reducing production and maintenance costs. *No. 289*

Seal And Spring In Toridal Inductor Made From Silastic

Superior resistance to compression set, even after prolonged exposure to high or low temperatures, has made Silastic*, Dow Corning's silicone rubber, increasingly popular among designers once hampered by the temperature limitations of organic rubber. Here, for example, is how Burnell & Co., Inc., uses Silastic to make a new variable toridal inductor more efficient and dependable at temperatures ranging from —100 to over 500 F.

The "Rotoroid" inductor comprises a toroid coil and two permanent magnets. One of the magnets is rotatable to produce a continuously adjustable biasing field for electronic circuitry. To provide a positive seal where the controlling shaft enters the unit's hermetically sealed housing, the shaft is fitted with a "Hexseal" locknut that has a heavy Silastic cover, molded by APM Co. To permit the shaft to turn freely, and yet maintain a tight seal, a very small amount of Dow Corning 200 Fluid, 1,000,000 centistokes, is applied to the well of the locknut.

Silastic also serves as a thrust and centering spring inside the "Rotoroid." Here a high durometer Silastic is used. In service this silicone rubber spring has proved to have excellent service life, retaining its original resiliency over a much wider temperature span than any metal spring.

In many electronic applications, such as guided missile telemetering systems, the thermal stability made possible through the use of Silastic parts, is vital to the "Rotoroid's" accurate performance. *No. 282*

*T.M. REG. U.S. PAT. OFF.

Silicone Lubricated Cartridge Improves .22 Rifle Performance

For the ultimate in accuracy and reliability leading designers of clocks and instruments years ago standardized on Dow Corning silicone lubricants. With a different kind of accuracy in mind, but one that requires the same calibre of precision performance, Remington Arms designers have specified a silicone lubricant for their new "Match 22" long rifle cartridge.

Custom-designed for target rifles, particularly the new 40X "Rangemaster" rifle, this cartridge features a new wind-bucking design, close-tolerance brass case, and an improved rim shape for better ignition. As the finishing touch, each "Match 22" is coated with a special lubricant based on Dow Corning 550R Fluid. This silicone lubricant keeps the cartridge clean and dry to the touch; does not foul the barrel; eliminates the need for cleaning the barrel between firing targets. Users report the silicone lubricant seems to add more accuracy to the bullet's flight. *No. 283*

SILICONE-GLASS LAMINATES *(continued)*

The extremely thin-walled construction of these parts provides more space for circulation of cooling air than possible with the several layers of tape conventionally used. In addition, the silicone-glass laminates are lighter in weight than the tape insulation. Quickly "snapped" into place, they effect substantial savings in assembly time and costs. *No. 281*

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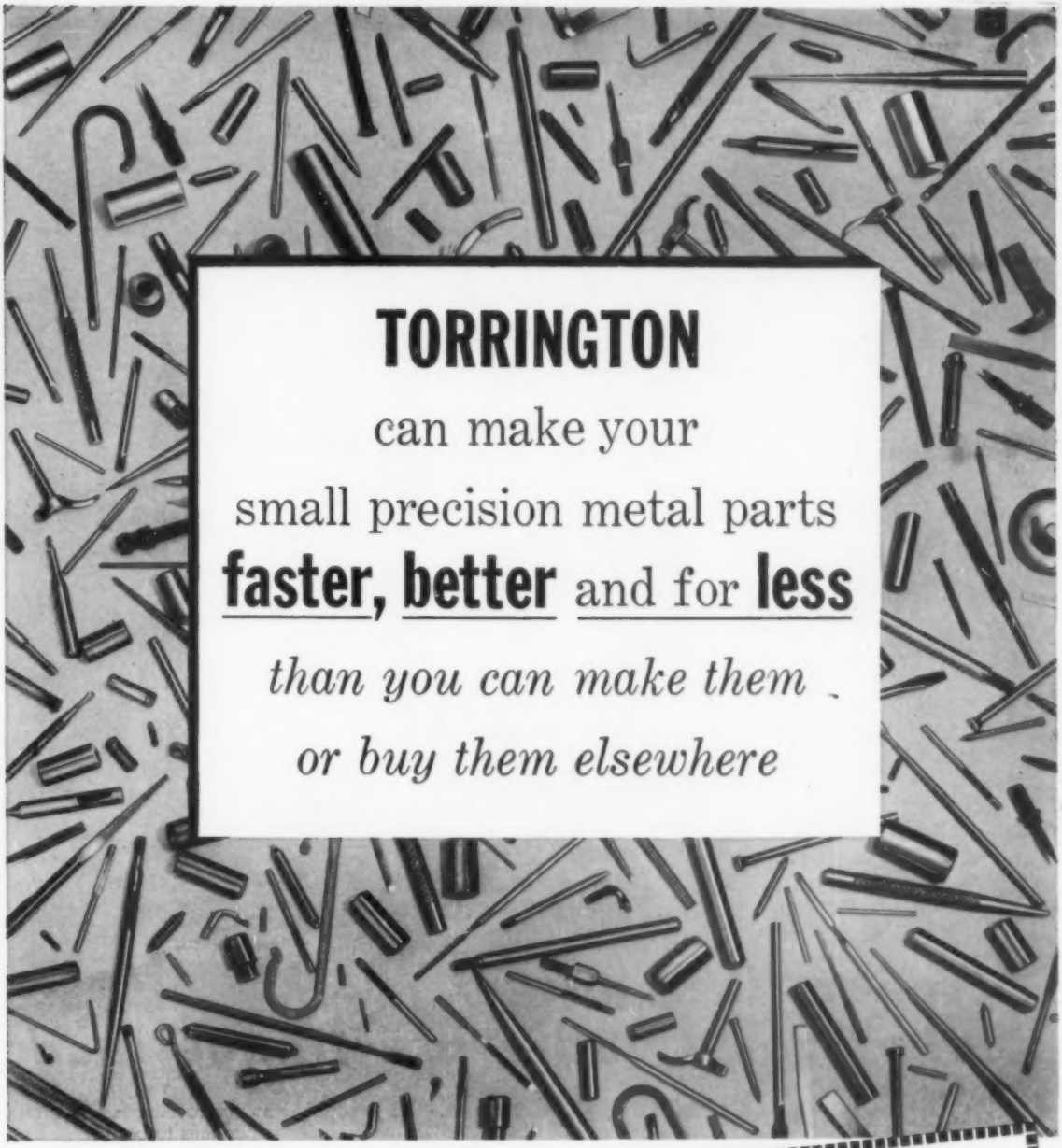

These are typical of parts that Torrington produces daily by the hundreds or millions. If you use similar small precision parts, mail the coupon today for the Torrington Small Precision Parts condensed catalog. Even better, send a sketch, blueprint or sample part. We will give you a prompt quotation which will mean substantial savings to you.

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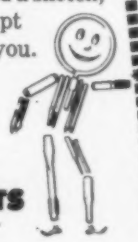

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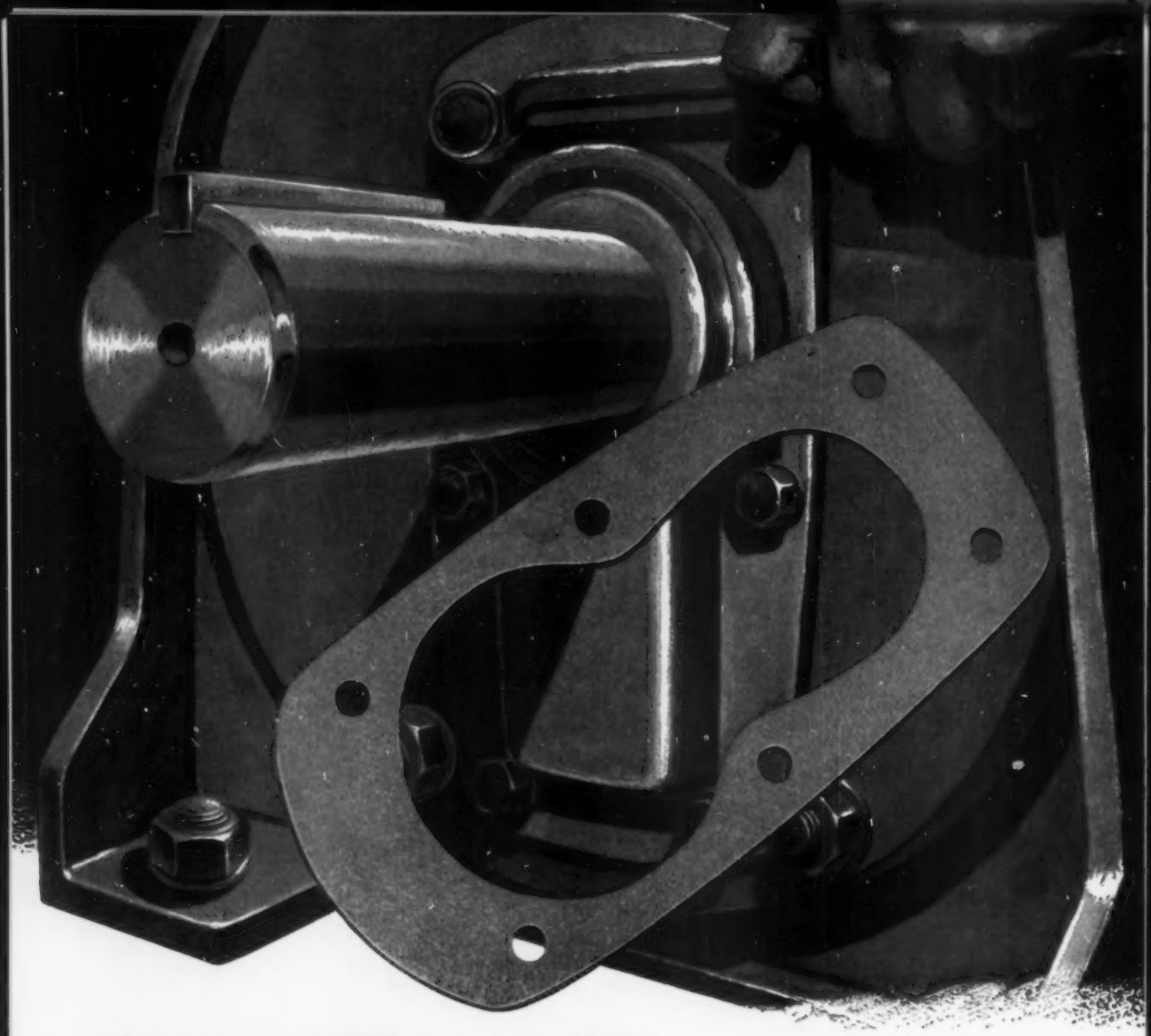
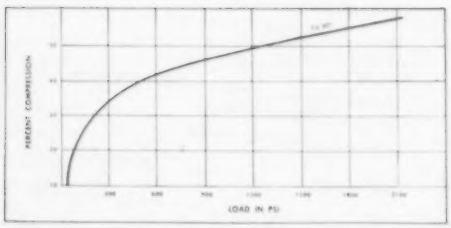


Accopac® fiber gasket seals tightly under low flange loads



HIGH COMPRESSIBILITY of Accopac CS-301 is shown by load-compression curve. With light metal flanges, this compressibility allows gaskets to conform to surface irregularities and form a tight seal without distorting flange.

Armstrong CS-301 Accopac is an improved beater-saturated gasket material that becomes impervious to both liquids and gases at flange pressures as low as 800 psi. This fiber-cork-rubber composition does an excellent sealing job in lightweight metal assemblies.

CS-301 Accopac is highly compressible and resilient. It conforms to normal surface irregularities on stamped flanges and on rough-finished cast flanges.

This unusual fiber material will not shrink or dry out; its special latex binder is non-volatile and non-extractable. CS-301 maintains a tight seal even in alternately wet and dry applications.

For more information and copy of "Armstrong Gasket Materials," write Armstrong Cork Company, 7007 Irvin Street, Lancaster, Pennsylvania.

Armstrong ACCOPAC

Cleveland Worm Gear Speed Reducers were specified and installed on these cage mills by the builders of the equipment—the Raymond Division of Combustion Engineering Co., Inc., Chicago, Ill.

8 CLEVELANDS drive cage mills at L.A. sewage treatment plant

STEADY, continuous operation is all-important here. Each of the 4 double cage mills in the Hyperion Treatment Plant of the Los Angeles Sewage Disposal Division are driven by 2 Cleveland Worm Gear Reducers of 30 HP capacity. Sewage sludge, reduced to 50% moisture, drops into the cage mills with furnace gases at 1300° F. Dried sludge and steam then pass through cyclone separators.

Cleveland Worm Gearing affords exceptional advantages for practically any power job. Steel worm on bronze gear provides the best possible medium to transmit power with minimum friction and wear—reduces motor speed evenly, efficiently, and quietly. Right angle drive makes a worm gear reducer compact and rugged, with few moving parts.

Get the full Cleveland story on power transmission. Write for Catalog 400; ask for technical advice on any problem you may have. The Cleveland Worm & Gear Company, 3279 East 80th Street, Cleveland 4, Ohio.

Affiliate: The Farval Corporation, Centralized Systems of Lubrication. In Canada: Peacock Brothers Limited.

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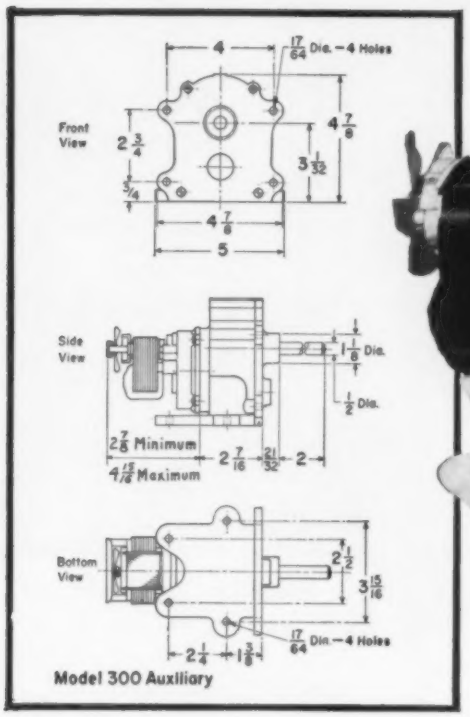

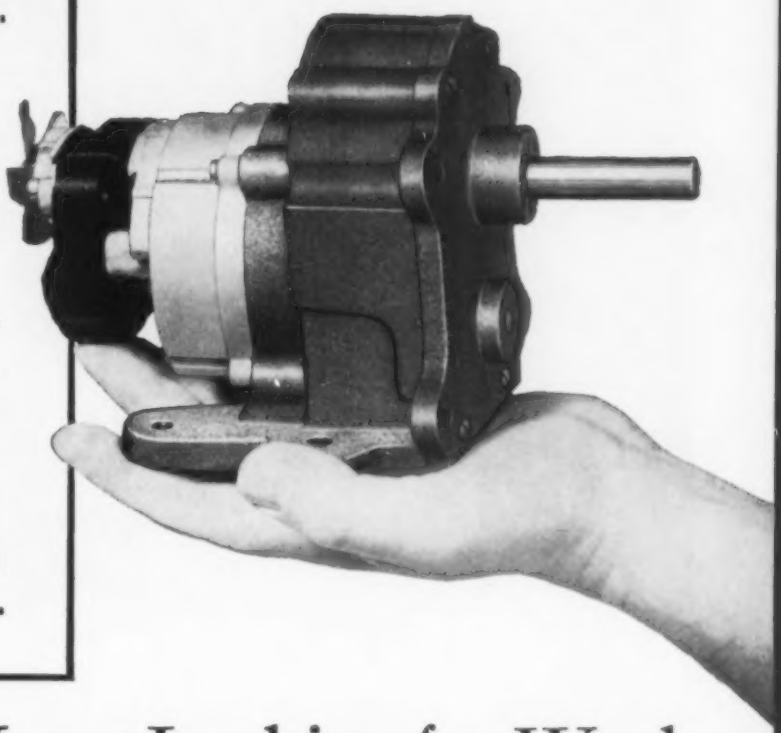

Here's a Motor Looking for Work

The newest in the line of Merkle-Korff fhp geared motors is the model #300 shown above. This unit, in continuous duty service, will deliver up to 300 lb. in. torque, yet it fits in the palm of your hand. The motor is ideally suited for applications requiring the operation of heavy cams, cranks or gears mounted directly on the motor shaft.

A typical torque table is shown below. This table shows no-load speeds for uni-directional shaded pole induction motors. The loads are the maximum under which the motor will start and operate continuously without over-load. The range of speeds shown are representative of those most commonly used. If the maximum rated torque is required at speeds greater than shown, modifications can usually be made, or the unit can be furnished at speeds as low as 1 RPH or slower.

This model #300 is only one of a long and varied line of Merkle-Korff fhp geared motors. They range in speed from 800 RPM down to any fractional RPM required. Merkle-Korff motors can be furnished either with induction shaded pole motors, or with synchronous, reversing, series, or shunt wound motors. These motors are furnished in a wide range of horse power ratings depending upon the output shaft torque requirements.

Merkle-Korff engineers will assist your design staff in specifying the unit best suited to your requirements.

TORQUE TABLE
MODEL 300

rpm	stator thickness		
	⅝"	1⅛"	1½"
10	25 lb. in.	33 lb. in.	60 lb. in.
8	30	40	75
6	42	54	100
5	50	65	120
4	62	80	150
3½	70	92	170
3	80	108	200
2½	100	130	240
2	125	162	300
1½	166	216	300
1	250	300	"
½	300	"	"

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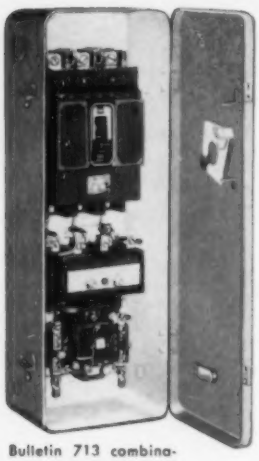
Hacksaws on shipping floor of Peerless Machine Company, Racine, Wis., all equipped with Allen-Bradley Bulletin 712 combination starters

ALLEN-BRADLEY COMBINATION STARTERS

Save Time · Neater Installations · Add Safety



Bulletin 713 combination starter with I-T-E instantaneous circuit breaker.

Machinery builders like the trim appearance of Allen-Bradley combination starters on their machines. Their customers like them, too, because they provide added safety to workmen. You can't open the cabinet unless the disconnect lever is in the "OFF" position.

The new Bulletin 712 combination starters have disconnects with contacts **plainly visible** when the switch is in the "OPEN" position — another safety feature. Bulletin 713 starters use an I-T-E circuit breaker as their disconnect.

Two thermal relays give continuously reliable overload protection and prevent costly motor burnouts. After tripping they are reset from the front of the cabinet.

For complete information, send for the Allen-Bradley Handy Catalog.

Allen-Bradley Co., 1329 S. First St., Milwaukee 4, Wis.
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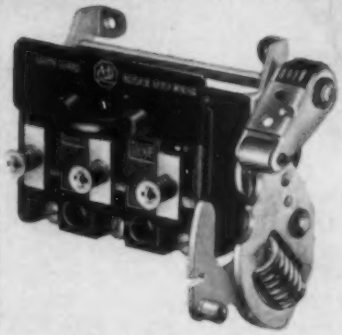
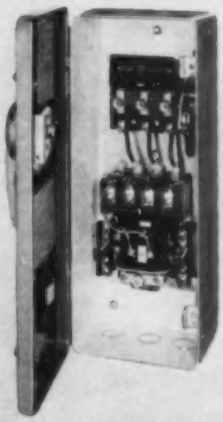
ALLEN-BRADLEY
QUALITY

BULLETIN 712-713 COMBINATION STARTERS

MANUAL DISCONNECT with visible contacts



Disconnect unit (with contacts visible in the "OFF" position) used in Allen-Bradley Bulletin 712 combination starters.



Bulletin 712 combination starter showing disconnect and magnetic starter in one enclosure.

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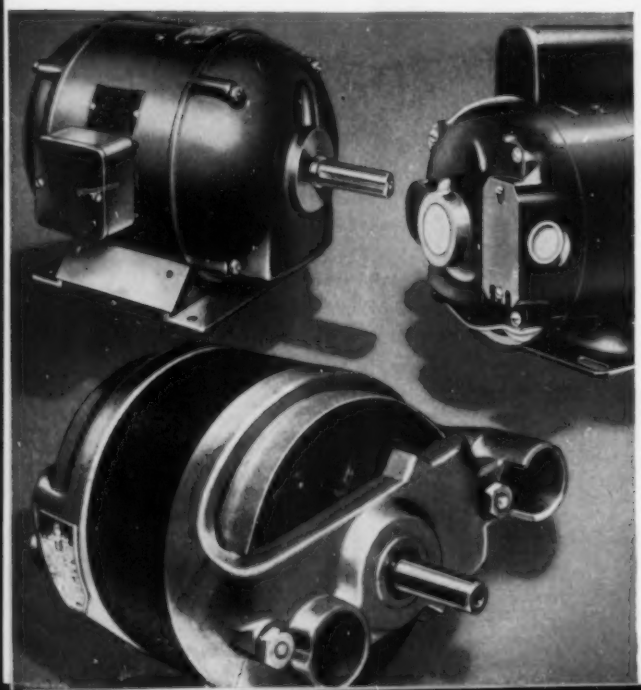
		Fans	Cast Cutters	Advertising Devices	Die Sinkers
		Sanders	Food Mixers	Ventilating Equipment	Waxers



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How General Electric Permanent Magnets help designers miniaturize products by supplying constant magnetic field energy in a fraction of the space required by electromagnets

WHERE constant magnetic field energy is necessary, powerful G-E Alnico permanent magnets offer the designer many advantages no electromagnet can match.

The most important of these advantages – from the designer's viewpoint – is the permanent magnet's superior volumetric efficiency. An Alnico permanent magnet can supply a given magnetic field in a fraction of the space required by even the best designed electromagnet.

Since miniaturization has become so vital in the electrical and electronics industries, it is important to see just why and how a permanent magnet utilizes space so much more effectively.

Figure 1 shows a typical magnetization curve of an electromagnet with a flux density of 20,000 gausses, when the polarizing force is 200 oersteds. (The curve has been displaced into the magnetizing quadrant for comparison purposes.)

In a well-designed electromagnet, approximately half the total area is occupied by conductors, and half is flux-conducting core material.

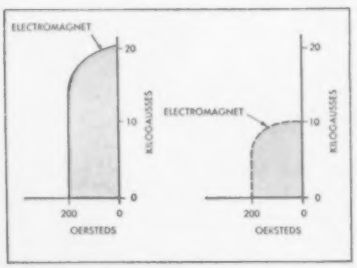

FIGURE 1

FIGURE 2

Therefore, to make the comparison valid, the residual induction of the electromagnet must be reduced to 10,000 gausses (Figure 2).

The area under the curve now represents the approximate external field energy available on a volume basis. When the equivalent demagnetization curve of Alnico 5 is plotted against the corrected electromagnet curve (Figure 3), the true capabilities of each type of magnet become immediately apparent.

The area under the Alnico 5 curve is about three times the area under the electromagnet curve. Thus, to produce a given field requirement, the permanent magnet will occupy a volume one-third that of an equivalent electromagnet.

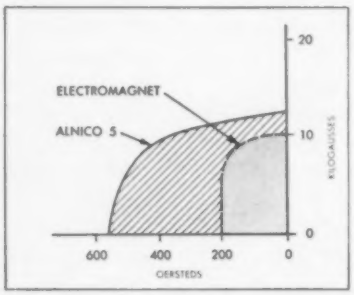

FIGURE 3

The above comparison is somewhat theoretical; under many circumstances, permanent magnets will show to even greater advantage. For example, consider the two TV-tube focusing magnets in Figure 4, at the top of the next column.

At the left, is the electromagnet previously used. It weighed 2 lbs. 13 ounces, and took up 16.35 cubic inches. At right, is the G-E Alnico 5 permanent magnet which replaced it. The new magnet weighs just 15 ounces, and occupies only 1.30 cubic inches – a space saving of 87%!

These savings in size and weight result from permanent magnets' inherent volumetric superiority. In addition, permanent magnets provide equally impressive savings in both initial and service costs because of four other inherent advantages.

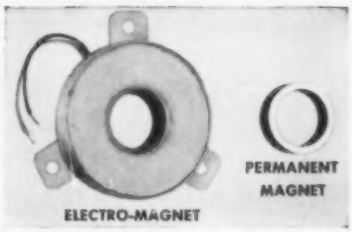

FIGURE 4

First, no power source is required with permanent magnets, because no energy is consumed. Once magnetized, the field is permanently retained.

Second, permanent magnets operate continuously. There can be no interruptions of the field due to power failure.

Third, permanent magnets are extremely stable under changing temperature conditions. They are unaffected by conditions ruinous to electromagnet installations.

Fourth, permanent magnet assemblies are easier to install, and cost nothing to maintain. There are no moving parts to break down, no wiring to burn out, no costly, time-consuming repairs to make.

These are but a few of the many reasons why designers are turning to G-E Alnico magnets for products for which only electromagnets had been previously considered.

If you have a problem where constant magnetic field energy is required, one of the G-E Alnico compositions may well be your solution. For more design data or technical assistance from our magnet engineers, write: *Carboloy Department of General Electric Company, 11127 E. 8 Mile Road, Detroit 32, Michigan.*

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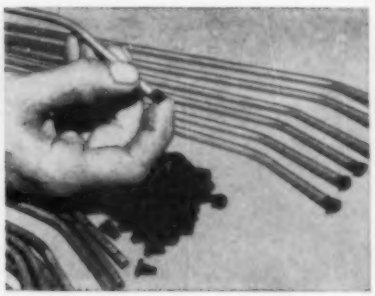
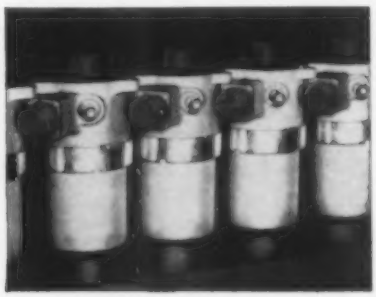


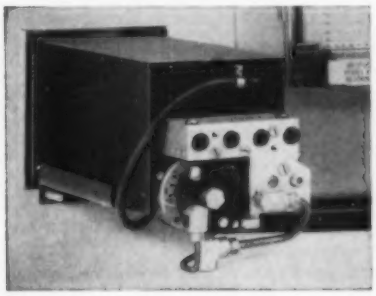
USED BY THOUSANDS OF INDUSTRIES

Here, CaPlugs are applied by Caterpillar Tractor Co., ". . . to protect and keep clean the tubing used in fuel injection equipment for diesel engines." Made of Polyethylene, CaPlugs will not collapse, chip, break or shred under most severe of conditions.



FIT MULTITUDES OF PRODUCTS

CaPlugs protect electrical connector fittings and armature shaft extensions of these electric motor assemblies. Here's sure, safe protection that's adaptable to all types of products and parts. (Photograph courtesy Pesco Products Division, Borg-Warner Corporation)



EASY TO REMOVE, TOO!

Installed on these Bristol air control instruments, CaPlugs prevent dirt or foreign matter from getting into the system before installation. Says The Bristol Company, "They are sturdy enough so that they are not accidentally dislodged, but are still easily removable."

INDICATES CARE IN MANUFACTURE

On this Alemite Accumatic Valve, colorful red CaPlugs add zestful eye appeal. Says Stewart-Warner Corp., "CaPlugs help impress the customer with the steps that have been taken to protect the equipment and convince him of the continuing need for protecting lubricants against contamination."

YOU NAME IT

There's a CaPlug to fit nearly every closure need. With six standardized designs (both threaded and non-threaded) and over 275 stock sizes available, "off-the-shelf" deliveries can be made to meet your immediate requirements without delay. Write for free samples and prices.

Free "see-for-yourself" assortment mailed on request

CAPLUGS DIVISION, PROTECTIVE CLOSURES CO., INC.
2205-9 Elmwood Ave., Buffalo 23, N. Y.

MAIL a free assortment of CaPlugs, literature and prices to us immediately, without obligation.

Name_____ Title _____

Firm _____

Address _____

City _____ Zone _____ State _____

CHASE® NICKEL LEADED COMMERCIAL BRONZE

For making STRONGER PRODUCTS *that have to be machined!*

This is the high-strength leaded commercial bronze you have been looking for! It has *27 percent higher tensile strength, 20 percent higher yield strength* than Leaded Commercial Bronze, yet has a machinability rating that is 80% of that of Free-Cutting Brass.

Chase Nickel Leaded Commercial Bronze is a moderately priced alloy for making longer-lasting pole line hardware, electrical fasteners, nuts, bolts, and other bronze products that require added strength. Order Chase Nickel Leaded Commercial Bronze today. It's available in rod form—round sizes from ¼" to 1" diameter, hexagonal sizes from ¼" to ⅞".

Chase

BRASS & COPPER CO.

WATERBURY 20, CONNECTICUT • SUBSIDIARY OF KENNECOTT COPPER CORPORATION

"IN THE CHIPS"—a Chase movie showing Brass Rod and Wire *at work*. Every machine shop can benefit by showing it. Loaned free on request.

The Nation's Headquarters for Brass, Copper and Stainless Steel

Atlanta • Baltimore • Boston • Charlotte • Chicago • Cincinnati • Cleveland • Dallas • Denver • Detroit • Grand Rapids • Houston • Indianapolis • Kansas City, Mo. Los Angeles • Milwaukee • Minneapolis • Newark • New Orleans • New York • Philadelphia • Pittsburgh • Providence • Rochester • St. Louis • San Francisco • Seattle • Waterbury

A new low price in "hi-fi" produced with DYLITE* polystyrene

Those versatile, puffable beads of DYLITE expandable polystyrene are opening the doors of "hi-fi" music to budget-minded people. It happened when Leonard Bonn, president of Plastilex Products, Inc., Philadelphia, used his imagination . . . and a few pounds of DYLITE expandable polystyrene.

"I first saw DYLITE advertised three years ago," said Mr. Bonn. "Although its use was not suggested for our field, I felt that the unicellular feature would absorb and prevent passage of sound, making it ideal for producing high fidelity equipment. Since spheres are recognized as the ideal sound baffle, experiments were run molding half spheres with copper hand molds. Gluing two halves together, we found that we had the ideal baffle, with the additional characteristics of lightness, low cost, and inertness to water, air and light."

After initial experiments, a "cycle control" compression molder was constructed to mass-produce the speaker shell. Using DYLITE, the beads were "popped" to twice their original size by pre-heating, then poured into the mold for treatment under heat, moisture and pressure. "The finished product has a relatively dense skin. It weighs only six pounds *with* speaker; it's strong enough to be bounced without breaking. The beads inside form a soft, resilient wall, permitting the inner surface to vibrate as an independent membrane, isolated acoustically from the outer wall."

Today, the "Bonn Sonosphere"† is providing low-cost "hi-fi" music for people who could never afford it . . . before DYLITE. We feel that DYLITE can solve problems in hundreds of as-yet-undiscovered fields of manufacturing. Perhaps your field is one of them. If you'd like to learn more about DYLITE, write to Koppers Company, Inc., Chemical Division, Dept. PE-76, Pittsburgh 19, Pennsylvania.

Koppers Trademark
†Plastilex Trademark

AT RIGHT
Mr. Leonard Bonn holds a model of his "Bonn Sonosphere" speaker, produced with DYLITE polystyrene.

BELOW
One-half of a "Bonn Sonosphere" still in the compression mold. Made with DYLITE, the completed sphere is an ideal "hi-fi" sound baffle, weighing just six pounds, including speaker.

KOPPERS

KOPPERS
PLASTICS

Sales Offices: NEW YORK · BOSTON · PHILADELPHIA · ATLANTA
CHICAGO · DETROIT · HOUSTON · LOS ANGELES · SAN FRANCISCO
In Canada: Dominion Anilines and Chemicals, Ltd., Toronto, Ontario

Remote or automatic switching

AT HALF THE COST

with Westinghouse motor-operated AB circuit breakers

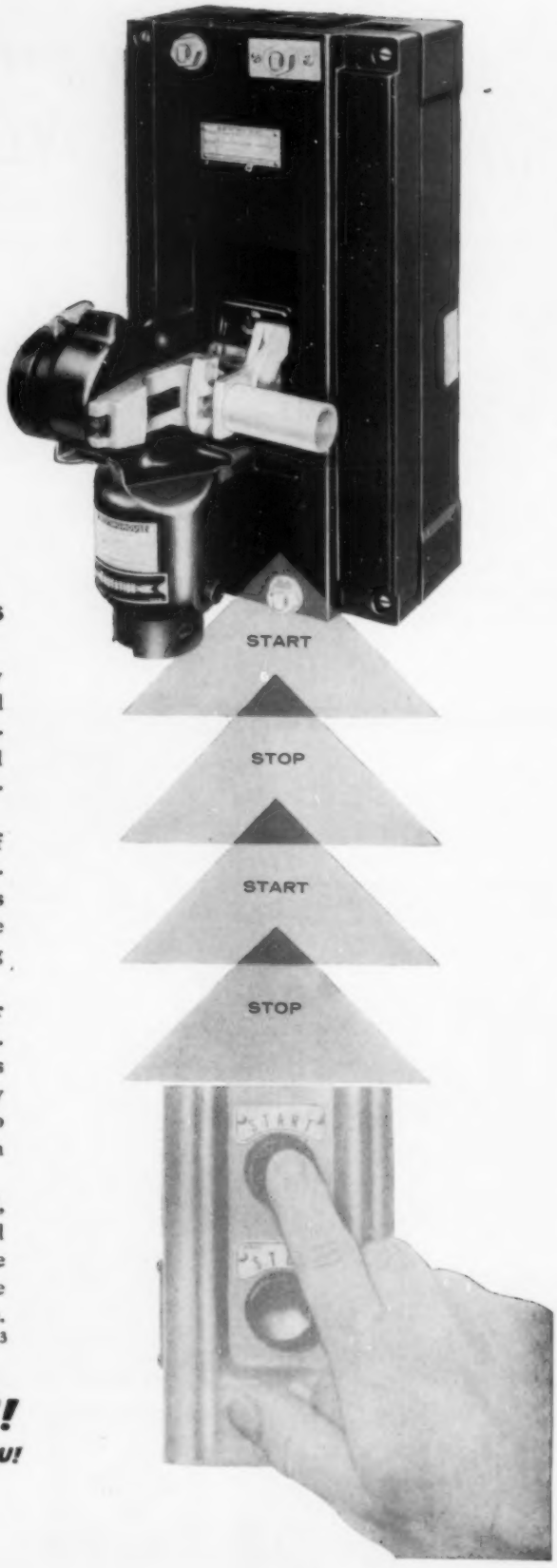
Now you can use a pushbutton or relay to electrically operate a Westinghouse AB circuit breaker. You can add load switching to your circuit protection — from a convenient point or under pre-determined conditions. And all without the need for a costly breaker-contactor combination or an expensive, large air circuit breaker.

Cost of the motor operator is but a small fraction of that for a large contactor. In fact, the complete dual-purpose breaker (breaker and motor operator) cost less than a contactor alone. Don't forget either the valuable space you save by eliminating contactors or by replacing larger breakers.

With the Westinghouse motor-operated circuit breaker you get all the proved AB De-ion® protection features. In addition you have your choice of such internal aids as reverse-current trips, undervoltage trips, and auxiliary or alarm switches. The motor operator can be applied to breaker Types J, K, KL, L and M in ratings of 70 through 800 amperes.

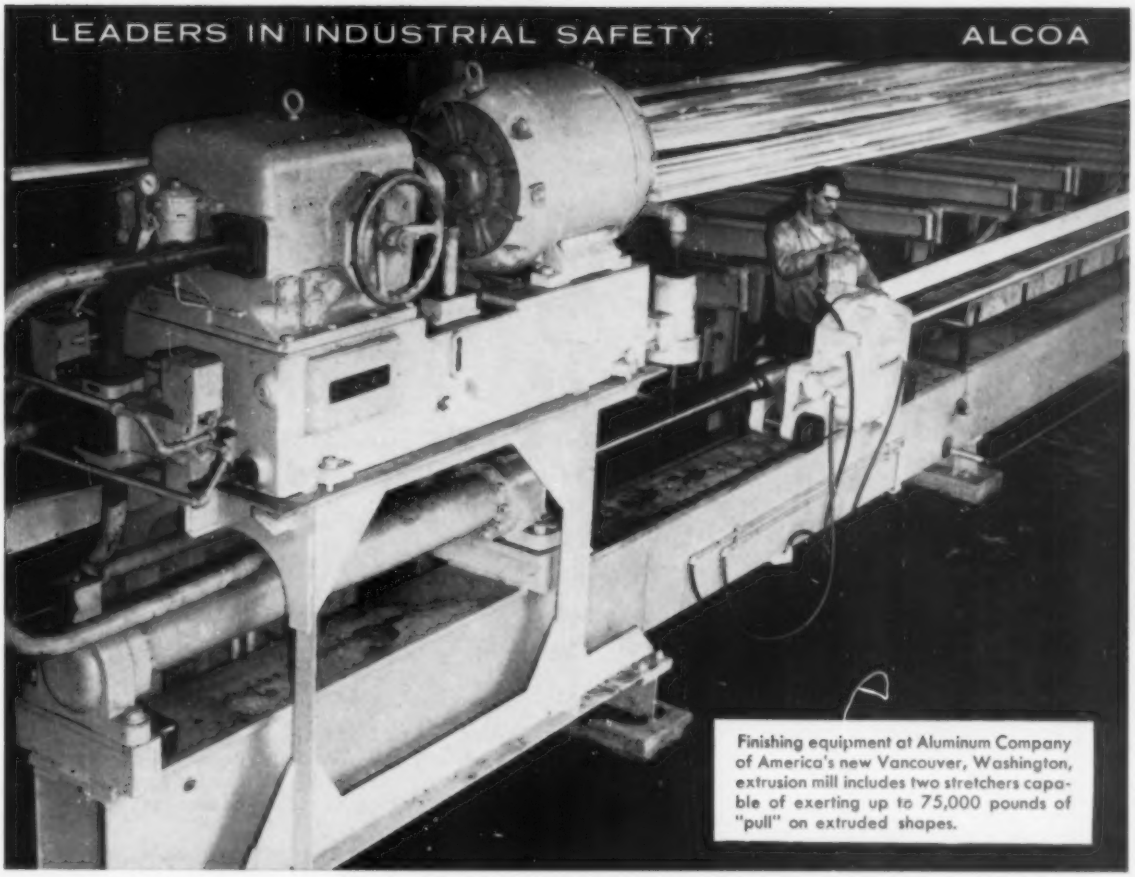
If it's remote or automatic breaker switching you need, consider the real savings possible with motor-operated AB circuit breakers. Your local Westinghouse sales office will be glad to help — or write direct to Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pa.

J-30213



WATCH WESTINGHOUSE!

*WHERE **BIG** THINGS ARE HAPPENING FOR **YOU!***


LEADERS IN INDUSTRIAL SAFETY:
ALCOA
Finishing equipment at Aluminum Company of America's new Vancouver, Washington, extrusion mill includes two stretchers capable of exerting up to 75,000 pounds of "pull" on extruded shapes.

One of the things that impresses visitors to Alcoa is the strong emphasis on safety. It isn't surprising, then, to find fire-resistant Pydraul used in Alcoa hydraulic equipment... eliminating a potential source of fire.

FIRE-RESISTANT PYDRAUL F-9 CHANGES FIRE ZONES TO SAFETY ZONES

275 million hours of actual in-use operation—without a single hydraulic fire—*proves* the safety and dependability of fire-resistant Pydraul hydraulic fluid.

But Pydraul gives you more than safety. You can be sure of long equipment life with low maintenance . . . because Pydraul lubricates like a premium petroleum oil. You'll save money on fluid consumption, too! Pydraul is reclaimable—you can return spillage to the system, use it again and again.

Make a quick check of your hydraulic equipment . . . calculate your fire risk if it's close to hot metal, electrical contacts, open flame or other heat sources. Then talk to a Monsanto representative. He will show you how easy it is to convert to Pydraul . . . giving you a future of positive safety from hydraulic fires . . . at low cost per year.

PYDRAUL MEANS:

Fire Resistance
Excellent Lubricity
High Stability
No Corrosion
Re-use, Again and Again

Write now for new booklet, "PYDRAUL F-9." Organic Chemicals Division, MONSANTO CHEMICAL COMPANY, Dept. PYD-1, St. Louis, 1, Mo.

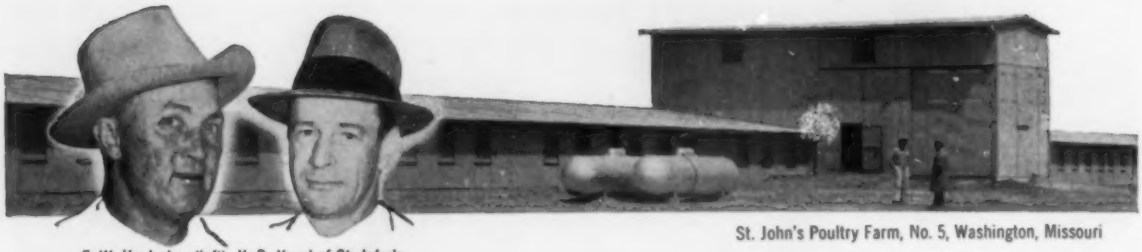
PYDRAUL F-9—First and Only Hydraulic Fluid Listed by Underwriters' Lab.

On May 31, 1955, Pydraul F-9 became the first fire-resistant hydraulic fluid listed by Underwriters' Laboratories. From the Laboratories' Service Card: "The fire hazard of (PYDRAUL) is rated 2 to 3 in accordance with Underwriters' Laboratories, Inc.'s Standard of Classification in which Ether rates 100, Gasoline rates 90-100, Alcohol (ethyl) rates 60-70, Kerosene (100° F. flash) rates 30-40, and Paraffin oil rates 10-20." See Underwriters' Laboratories, Inc.'s guide No. 540 18, File MH6049.

PYDRAUL: Reg. U. S. Pat. Off.

MONSANTO

WHERE CREATIVE CHEMISTRY WORKS WONDERS FOR YOU



St. John's Poultry Farm, No. 5, Washington, Missouri

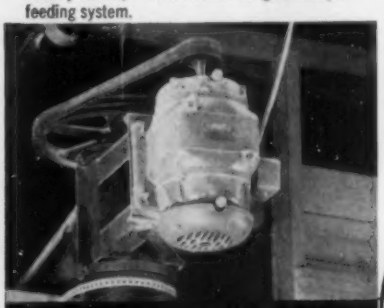
F. W. Hoelscher (left), K. B. Kruel of St. John's Poultry Farms, Inc. Hoelscher designed unique feeding system.

Baldor

STREAMCOOLED MOTORS

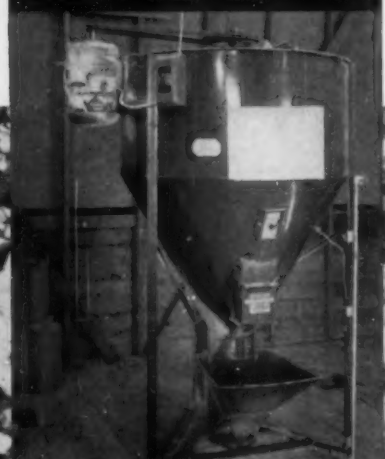
help feed 120,000 chickens

Automatically!



Vertically-mounted, 2-HP Baldor Motor drives screw elevator which lifts corn grain from ground level into hopper for storage.

Hammer mill, powered by a 5-HP Baldor Motor, grinds grain and blows it to weighing bin and mixer.



Special feed is mixed with ground corn. Vertically-mounted, 3-HP Baldor Motor drives mixer. All motors are single phase.

St. John's Poultry Farms, Washington, Mo., boasts one of the most time and labor saving systems for feeding chickens in the world! Six block-and-a-half long broiler buildings house 20,000 chickens each. *One man* maintains each building.

Many Baldor Streamcooled Motors power these automatic feeding systems. Splash-proof, dust-proof, totally enclosed motors keep out powder-like grain that constantly fills the air. Non-clogging external fans can't cause trouble that might stop entire system.

These same rugged Baldor Motors—proven in field use for over a third of a century—have also earned an outstanding reputation among OEM users. Baldor engineering counsel is available—without obligation—to help solve your knotty motor problems. Just contact . . .

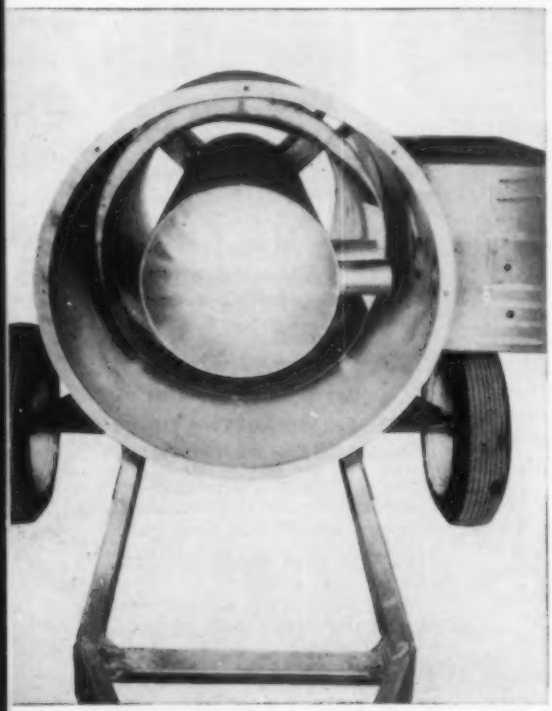
BALDOR ELECTRIC CO.

4353 Duncan Avenue • St. Louis 10, Missouri

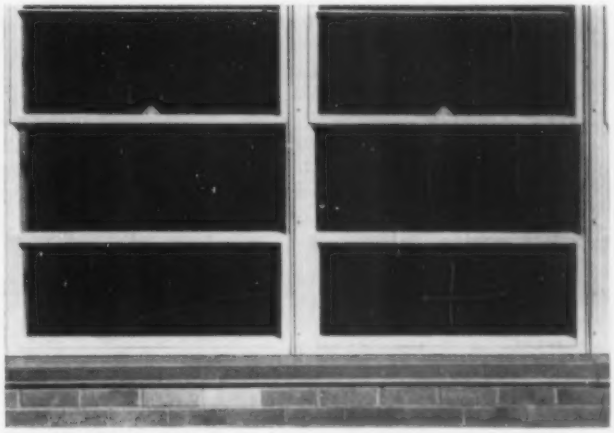
Chain belt carries feed in adjustable-height troughs to 20,000 broilers. Automatic timer increases frequency of delivery as chickens mature. Human hands never touch grain during entire process.

FOR TRAILERS THAT DO NOT WEAR OUT. This Fruehauf trailer has sides made from thin sheets of Stainless Steel, corrugated into walls that are only one inch thick. That's why it can carry more cargo than trailers of other, heavier types of construction. Most joints are welded, an easy job with Stainless. There is nothing to corrode or loosen; in fact, no Stainless trailer has ever worn out!

NOTHING *can equal Stainless Steel*



FOR HEAT RESISTANCE. This is a Lennox Crop Dryer. It burns 12 gallons of fuel oil per hour and has an input of 2,000,000 BTU. Wherever the heat is most intense, type 430 Stainless Steel is used. It is especially important for the combustion chamber and emitting tubes.



FOR ARCHITECTURAL USE. This Dawson Floating Sill is made from type 302 Stainless Steel. It combines fine appearance with the enduring properties of Stainless Steel. The finished job is neat and trim, and it will last as long as the building.

UNITED STATES STEEL CORPORATION, PITTSBURGH • AMERICAN STEEL & WIRE DIVISION, CLEVELAND
COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO • NATIONAL TUBE DIVISION, PITTSBURGH
TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA.
UNITED STATES STEEL SUPPLY DIVISION, WAREHOUSE DISTRIBUTORS
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

USS STAINLESS STEEL

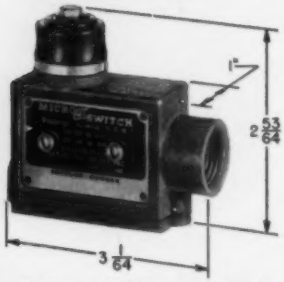
SHEETS · STRIP · PLATES · BARS · BILLETS
PIPE · TUBES · WIRE · SPECIAL SECTIONS

USS

UNITED STATES STEEL

Uses Unlimited for

3 switches control functions of precision grinder



Rugged day-in, day-out service to precision-grind 380 piston assemblies an hour demands components of the utmost long life and dependability.

Designers of the centerless grinding machine which performs these operations chose three MICRO SWITCH precision switches to signal and control the various steps of the loading and unloading cycle.

This selection, they told us, was because:

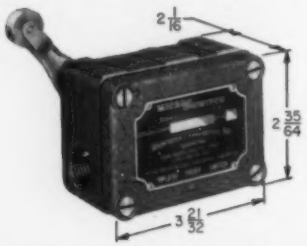
MICRO SWITCH provides the largest selection of oil-tight switches of the type required.

MICRO SWITCH national distribution makes switch replacement a simple matter.

MICRO SWITCH field engineering service is quickly available.

Switches perform 3 different functions in rotary cutter-winder

Small, compact, well-protected switches were required by the designers of a rotary cutter-winder used in the textile industry.



Each switch performs a separate and distinct function. The MICRO precision switches were selected because of their ability to best meet these diverse requirements:

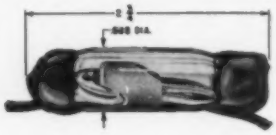
A switch (shown) prevents operation of the cutter frame if the new shell is not in position.

Another switch, which has high inrush capacity, operates the starting motor.

A ruggedly housed switch operates a 4-way solenoid pneumatic valve to raise and lower the cutter frame.

Mercury switch gives alarm protection for plant windows

A company which supplies plant protection services found HONEYWELL mercury switches ideally suited to their design requirements.



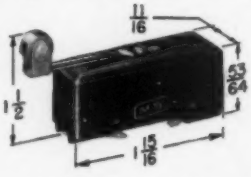
The switch is attached to horizontally pivoted windows of the fenestra or projected type.

When the window is closed, the switch is in the normal or protected position. Opening of the window activates the mercury switch and causes the alarm to be sounded at a central station.

These versatile switches perform excellent service in a wide variety of applications where tilt motion is present and low operating force is desired. Often the proper tilt motion can be developed by consultation with MICRO SWITCH engineering service.

24 switches of 8 different types control robot washer operation

Design engineers chose MICRO precision switches to control every step of a fully automatic commercial



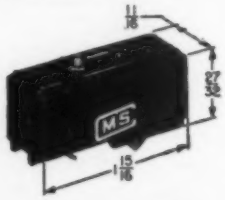
washing machine. 24 switches of 8 different types control the measurement of water, temperature, timing of washing cycle, steam injection and dumping water at cycle's end. MICRO SWITCH units were selected because of their long-life, dependability, and high electrical capacity. Their use was an important factor in making possible this completely automatic washer.

MICRO SWITCH ability to provide a wide range of switch types to meet every switch requirement is the reason design engineers rely on MICRO precision switches as components for new and improved products.

MICRO SWITCH gives "push button" operation to coffee brewer

Four MICRO precision switches help provide precise control of every brewing factor of a well known commercial coffee maker.

These high capacity switches automatically measure the amount of water and control the temperature and infusion time. All switches handle high inrush current.



Designers of the coffee brewer picked MICRO SWITCH units for this device because of their ability to meet the requirements of:

Long-life reliability
Quick, positive action
High electrical capacity

Let MICRO SWITCH Engineering Service be your short cut to better design

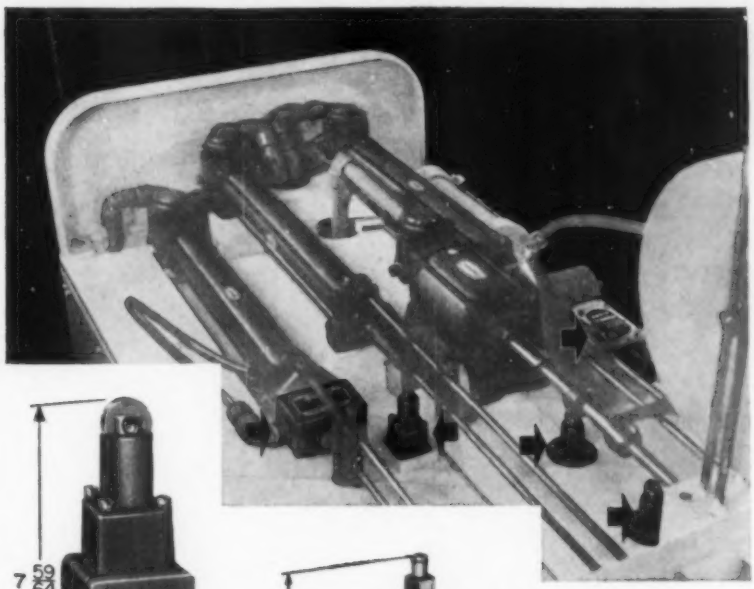
MICRO SWITCH Engineering Service is made up of experts on just one thing —precision switching problems.

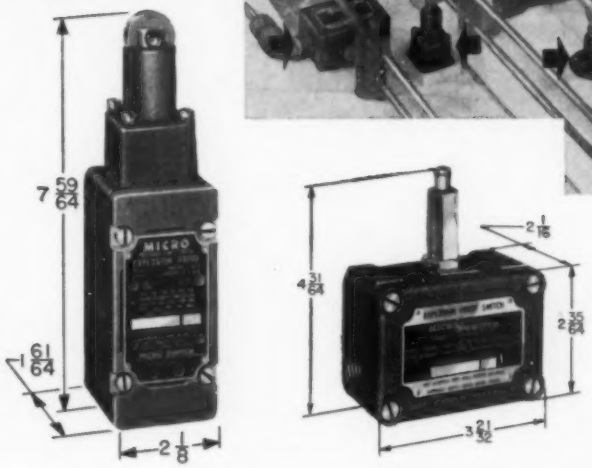
Whatever your design problem, its solution may easily be expedited by consultation with an engineering service that has helped in the solution of many complex electrical switching problems.

MICRO SWITCH may have already solved a problem similar to yours—for somebody else. Should your problem turn out to be entirely new, MICRO SWITCH can—and will—develop the switch you need.

MICRO *precision switches*

...THEIR USE IS A PRINCIPLE OF GOOD DESIGN





9 Explosion-Proof Switches Control Machine Making Shell Primer Bodies

MICRO SWITCH explosion-proof switches—of two different types—enable this ingenious machine to prepare primers, under hazardous atmospheric conditions, for artillery shells.

In one streamlined operation, all handwork is eliminated as this diaphragming machine lacquers the interior of the primer body; punches and forms diaphragms from a paper roll; seats diaphragms to proper depth and provides final inspection of finished parts.

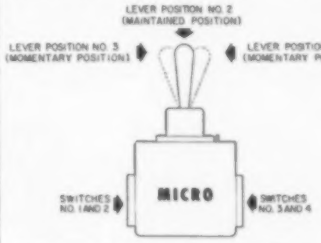
Shown here is the rotary index table which is controlled by MICRO SWITCH explosion-proof switches. Five of the nine switches used may be seen.

This is a typical example of the important part played by MICRO SWITCH products and MICRO SWITCH engineering service in the development of automatic machinery to serve a wide range of industrial applications.

NEW!

An "Electrical Memory" Toggle Switch

Here is the first in a new series of "electrical memory" toggle switches. It is a four-pole assembly with one pole to indicate which circuit was last operated. It promises to simplify and perhaps revolutionize some basic circuit designs of complicated ground radar units, computer devices, aircraft control panels and other types of remote control equipment.


LEVER POSITION NO. 2 (MAINTAINED POSITION)
LEVER POSITION NO. 3 (MOMENTARY POSITION)
LEVER POSITION NO. 1 (MOMENTARY POSITION)
MICRO
SWITCHES NO. 1 AND 2
SWITCHES NO. 3 AND 4

	Lever Position No. 1	Lever Position No. 2	Lever Position No. 3
Switch No. 1	N.O. To C. Circuit Made	N.C. To C. Circuit Made	N.C. To C. Circuit Made
Switch No. 2	N.O. To C. Circuit Made	N.C. To C. Circuit Made	N.C. To C. Circuit Made
Switch No. 3	N.C. To C. Circuit Made	N.C. To C. Circuit Made	N.O. To C. Circuit Made
Switch No. 4	N.C. To C. Circuit Made	*	N.O. To C. Circuit Made

*N.C. To C. Circuit Made if Lever Last Moved To Lever Position No. 1
*N.O. To C. Circuit Made if Lever Last Moved To Lever Position No. 3

The assembly uses three single-pole, double-throw functional basic switches and one single-pole, double-throw "memory" switch.

In application the "memory" switch indicates through a pilot light or buzzer which circuit was last operated.

The three functional switches operate at three lever positions: maintained center and momentary from each extreme position.

Electrical rating of basic switches: 5 amperes 125 or 250 volts a-c. The d-c rating at 30 volts: inductive—3 amperes at sea level and 2.5 amperes at 50,000 ft.; resistive—4 amperes at sea level and 4 amperes at 50,000 feet; maximum inrush—15 amperes.

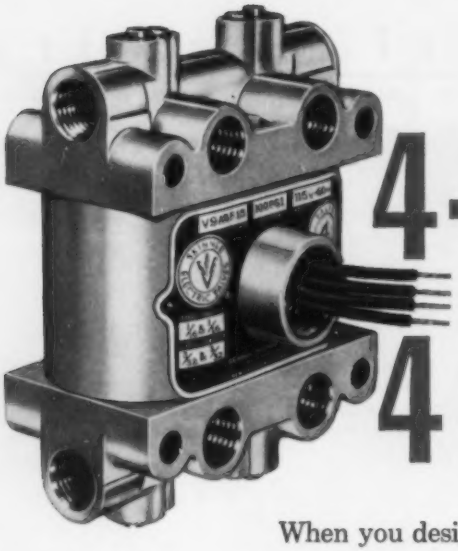
Send for new Catalog 83 on Industrial enclosed switches.

For more complete information on this new switch or any MICRO SWITCH *precision switch, contact the branch near you.*

MICRO SWITCH

A DIVISION OF MINNEAPOLIS-HONEYWELL REGULATOR COMPANY

In Canada, Leaside, Toronto 17, Ontario • **FREEPORT, ILLINOIS**



4-WAY for 4 REASONS

When you design or modernize equipment, look into the four big reasons for using Skinner's low-cost V9 Solenoid Valve. 1. Only 4 5/10" high, the V9 fits nearly anywhere, saves space, yet is powerful enough to operate single- and double-acting cylinders. 2. Available in more than 176 variations of capacities, metering and types; it can be used with air, inert gases, hydraulic oils and other common media at 0-150 p.s.i. 3. The V9 provides leakproof, dependable, *fast* operation — up to 600 cycles per minute in many applications. 4. Its rugged, frictionless construction and precision engineering ensure life spans of *millions of cycles,* eliminating replacement and maintenance problems.

For complete information, write for Catalog D2.

SKINNER SOLENOID VALVES

SKINNER ELECTRIC VALVE DIVISION • SKINNER CHUCK COMPANY

THE CREST OF QUALITY

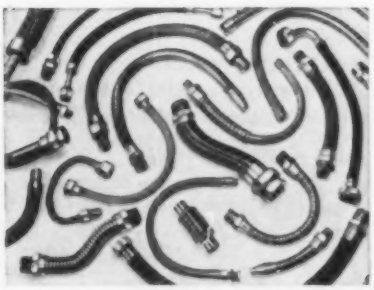
SKINNER ELECTRIC VALVES ®

114 Edgewood Avenue
New Britain, Conn.

WORLD-WIDE REPRESENTATION

American Vibration Eliminator absorbs vibration in piping leading from refrigeration compressor . . . stills noise, ends piping failures.

Standard line of flexible metal connectors simplifies isolation of vibration in rigid piping



Typical American flexible assemblies available to convey both liquids and solids, absorb vibration, compensate for contraction and expansion in rigid piping; connect moving parts, misaligned ports; and to protect delicate tubing, wiring.

UNCONTROLLED vibration in pipelines often results in objectionable noise, cracked piping, high maintenance costs, and expensive shutdowns.

American engineers have designed a number of flexible metal hoses, connectors and conduits that are widely used by design engineers and others to solve this problem.

American Vibration Eliminators (illustrated here)—short sections of seamless flexible bronze (98¾% copper, 1¼% tin) tubing used to minimize noise and vibration in rigid piping of air conditioning, refrigeration and other installations may be adapted to your product or problem.

Flexpipe* standard flexible connectors—seamless, tin bronze tubing, corrugated for flexibility, with tin bronze wire braid covering—used in wet heat systems by contractors, and in other installations to convey air, gas, oil, steam or water, dampen noise in piping, take care of expansion and contraction, simplify installations.

Sealtite* flexible, liquid-tight conduit—tough polyvinyl chloride jacket extruded over flexible metal core—protects wiring outdoors and in . . . in wet or corrosive spots. Highly flexible: takes up movement, absorbs vibration, easily installed.

Whatever your piping problem, there is a standard American flexible metal assembly right for the job, or American engineers will design one to your specifications at no extra cost. For more information, write for Catalog CC-400. The American Brass Company, American Metal Hose Division, Waterbury 20, Conn.

*Trade Mark

56176

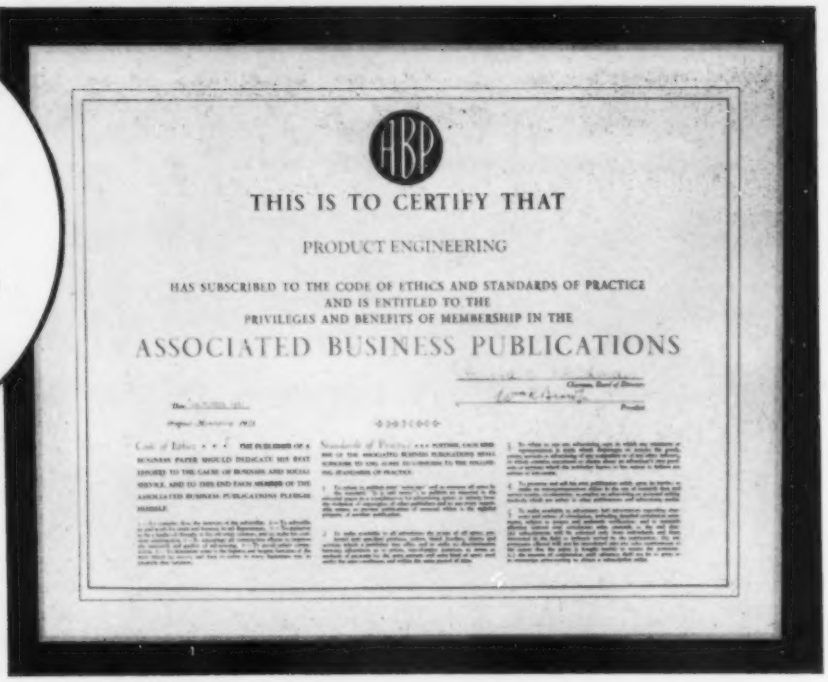
WHEREVER CONNECTORS MUST MOVE

AMERICAN

FLEXIBLE METAL HOSE AND TUBING

an **ANACONDA**® product

"TO CONSIDER **FIRST** THE INTERESTS OF THE SUBSCRIBER"



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Product Engineering

Designer's Digest

PRODUCT HIGHLIGHTS

General Electric Speed-Measurement Systems Now Tailor-Made to Suit Your Needs

These low-cost and highly accurate components add beauty and quality to your product.

General Electric's complete line of a-c and d-c tachometer generators and indicating or recording instruments provide you with a low-cost answer to your speed measuring problems. Every system is tailor-made to your needs and all components are calibrated together at the factory to assure you highly accurate operation on your equipment.

SMALL IN SIZE, these tachometer generators are ideal for measuring speed on machines where space is at a premium and where accurate speed indication is necessary for quality control and protection of expensive machinery.

TOTALLY ENCLOSED, all G-E tachometer generators are protected from dirt, dust and other foreign matter which might affect operation.

ANY LEGEND you desire will be marked on your G-E tachometer indicator scales. Your instrument can be calibrated in units such as feet per minute, inches per minute, spindle rpm or any related speed. Manufacturer's or customer's name may also be imprinted on the scale face.

FOR GENERAL-PURPOSE NEEDS, a Model 1E148 tachometer generator used with a Type DB-18 tachometer indicator provides a speed measurement range of 100 to 5000 rpm.

LOW-COST SPEED CONTROL, as well as accurate speed indication, is furnished by G.E.'s D-C tachometer generator 9894743 in a wide variety of applications.

FOR MORE INFORMATION write for Bulletin GEC-1258 to Section 585-43, General Electric, Schenectady 5, N. Y.

HANDSOME DESIGN and top quality of DB-18 indicator help make your product more saleable. Long scale and clear, shadow-proof glass give telescopic readability.

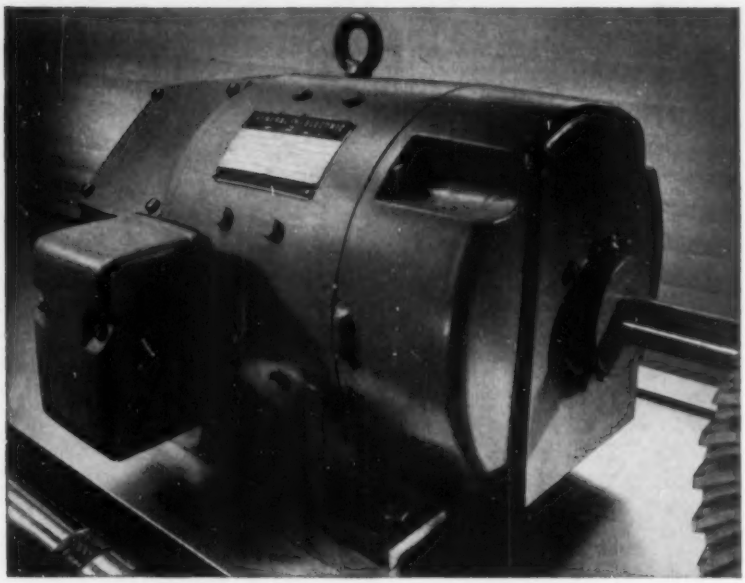
WEIGHING ONLY 5 POUNDS this 1E148 generator has a speed range of 100 to 5000 rpm and is suitable for most general-purpose needs.

DESIGNED FOR MINIMUM SPACE, this 9894743 generator can be either flange or foot mounted. Two models: 50-v or 100-v per 1000 rpm.

TURN THE PAGE FOR MORE G-E PRODUCT HIGHLIGHTS

Designer's

New KINAMATIC† d-c motors give the machines you build greater output



To meet modern industrial needs for faster, more automatic, more continuous production, General Electric has designed an entirely new direct-current motor—the d-c Kinamatic.

Designed for Automation—Now, a direct-current motor has been designed for the modern job it has to do—either as individual motor drive or in regulating systems. The new General Electric d-c Kinamatic motor supplies the wide speed range and versatility required for today's manufacturing methods. It is designed for the close control of machines and split-second timing of processes essential to higher output.

Accelerated Production—The new d-c Kinamatic motor will modernize your equipment, give it increased power, higher speeds, greater output capacity. With the quicker acting General Electric Kinamatic motor, your machines will process a greater variety of products . . . faster . . . easier . . . and with less maintenance and spoilage.

More Powerful—By combining advanced design with improved materials and manufacturing techniques, General Electric engineers have packed more power into the entire Kinamatic line. The powerful Kinamatic motor, with new stamina and durability, is ready to become one of industry's most effective weapons for keeping costs down, for meeting competition, for boosting productivity levels.

Convenient, easily adapted accessories and modifications add even greater versatility to Kinamatic motors, often reduce need for "specials," permit switching motors from one application to another to reduce spare-motor and spare-parts inventories. Ratings from 1 to 150 hp are included in the line. See GEA-6355.

†Trade mark of General Electric Co.

Vac-u-Sel* rectifiers reduce design space by 50%, cost less

Because Vac-u-Sel rectifier cells can be operated at higher current and voltage ratings and still provide the same life expectancy of ordinary selenium rectifiers, a stack for a given application can be assembled using fewer and smaller cells. This can result in a size reduction up to 50% and at an appreciable savings.

If you need longer life, greater dependability, and better performance, you can operate the Vac-u-Sel rectifiers at their handbook ratings. This will give you a life expectancy of up to 80,000 hours which is about ½ more than is available from most ordinary selenium rectifiers under the same conditions.

G-E design engineers are able to accurately predict the output and life characteristics of any Vac-u-Sel model number. With this in mind General Electric has developed a special Application Manual with which you may design your own rectifier stack to meet the exact requirements of your application. In this manner, you can select what you need in terms of life expectancy, performance, size, and cost. What is more, over 17 years of experience with selenium cells manufactured by the precisely controlled vacuum process will aid you in designing toward predictable, continually reproducible performance. Write for a copy of Application Manual GEC-1330.

*Reg. Trade mark of General Electric Co.

GENERAL ELECTRIC

Digest

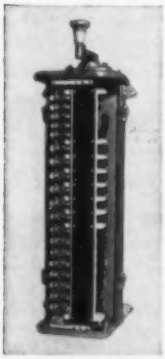
PRODUCT HIGHLIGHTS

New enclosed coolant pump motor keeps out dirt, metal shavings

Designed especially for driving machine-tool coolant pumps, this new General Electric fractional-hp motor is totally enclosed, non-ventilated to minimize the danger of damage from dirt and metal particles and to assure dependability of operation.

For long bearing life, the motor has large grease reservoirs, which assure a supply of a new, moisture-resistant grease for up to 10 years. In addition, the motor can be mounted horizontally or vertically. Available in ratings from ¼ to ¾ hp. See GEC-1353.

Drum switch assures you easy installation, reduced maintenance

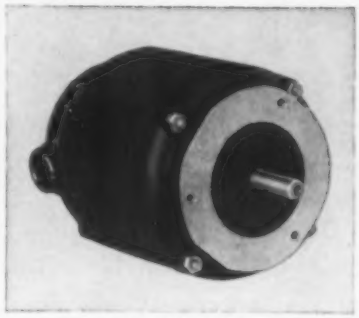


General Electric's complete line of drum switches are especially designed for starting and intermittent operation. They can be used with magnetic line starters to provide undervoltage and overload protection, limit switch control, or interlocking with other drives.

Combination knockouts simplify connections from bottom, back, or sides on conduit boxes. Finger contacts can be reversed after one side is worn so that the second side is completely used before replacing. Compensation adjustment for finger and segment wear is easily accomplished with a screw driver. For drum switches, check GEA-6307.

Low-speed synchronous inductor motors provide versatility, long life

Use these General Electric fractional-hp motors for high torque, low synchronous speed applications requiring frequent starts, stops, and reversals. Because the input current is nearly constant for various load conditions, these motors can be stalled continuously without damage from overheating. Only one moving part and lubricated-for-life bearings mean long life and low maintenance on your applications.



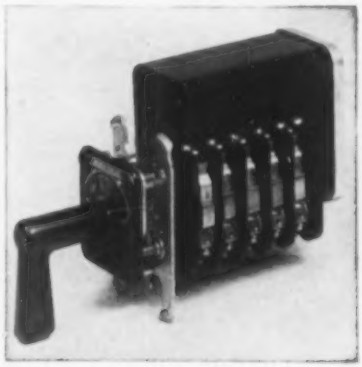
Type SMY Motor, 54-frame

Available in two ratings, 75 oz. in. continuous at 40 C and 150 oz. in. intermittent for ½ hour at 55 C, there are a number of models from which to choose. These are used on motor-operated valves and rheostats for remote or automatic control, and on industrial process timers. Sufficient torque is developed to operate cams, levers and other devices; often replacing a second motor. Low speed and rapid deceleration have enabled it to actually replace the gear-brake motor as a film-wind drive on an automatic camera and on a tape dispensing machine. Using a special circuitry has made possible step motor operation—moving a definite number of degrees for each power impulse applied—for computer and metering applications. Write for GEC-1294.

Compact SB-1 switch gives you long service life

The Type SB-1 switch is a rotary cam-operated device designed primarily for the control of electrically-operated circuit breakers, small motors, magnetic switches, and similar devices.

Standard SB-1 switches are designed to meet most applications. However, if you have a special application, a switch can be built from standard parts to meet your requirements. Long wearing cams, positive wiping action of the silver-to-silver contacts, and positive contact opening and closing action through cam pressure all combine to provide a high quality switch that will give you long dependable life. Write for GEA-4746.



General Electric Co., Apparatus Sales Division, Sec. Au68-130, Schenectady 5, N. Y.

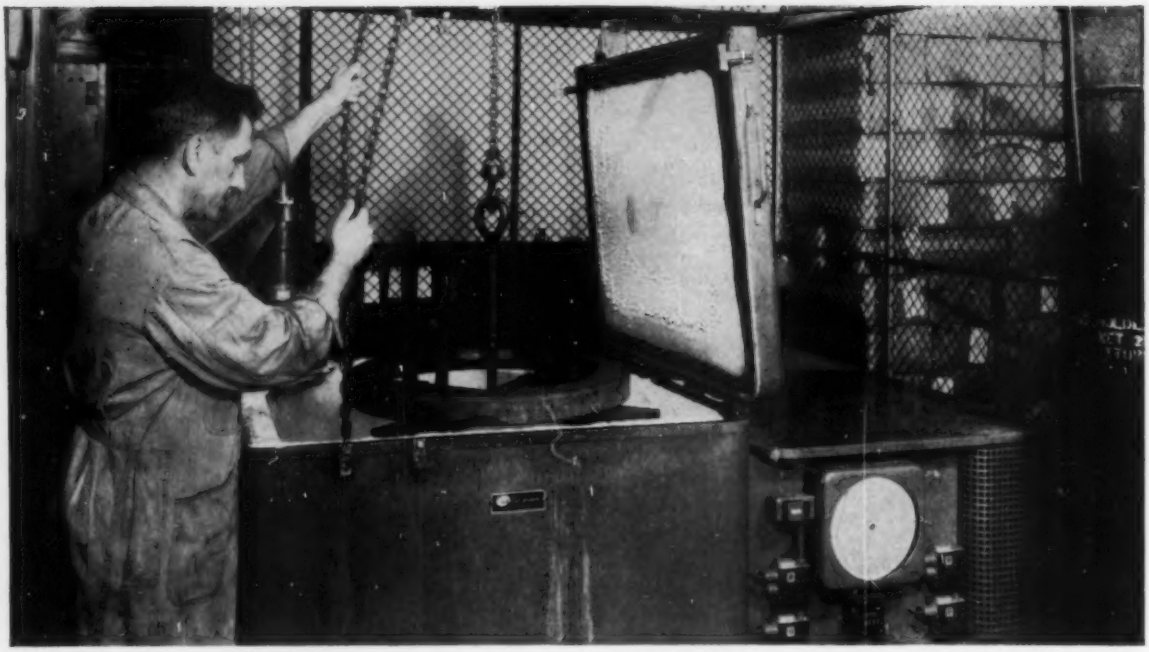
Please send me the following bulletins:

√ for reference purposes X for immediate project

- ☐ GEC-1330 Vac-u-Sel Rectifier Application Manual
- ☐ GEA-6307 Drum Switches
- ☐ GEA-6355 Kinamatic motors
- ☐ GEC-1294 Synchronous inductor motors
- ☐ GEC-1353 Coolant pump motors
- ☐ GEA-4746 Control and Transfer Switches

Name..... Company.....

City..... State.....



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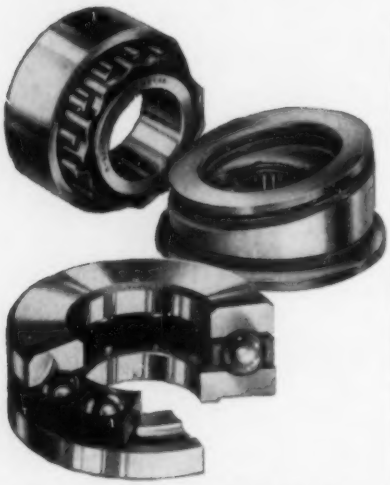
to give you better, more dependable anti-friction performance



Typical examples of Special Aetna Super-Precision Bearings . . . manufactured to the most advanced dimensional control standards including stabilization.

Looks warm and comfortable, doesn't he?—the operator pictured here. Actually he's only inches away from one of industry's coldest work spots—the "deep freeze" vault where Aetna bearing components are treated at temperatures as low as 130 degrees below zero.

This special sub-sub zero treatment makes certain that vital Aetna bearings built into high precision products will provide the dimensional stability so necessary for sustained peak efficiency and longest life expectancy. In this quick-aging process the steel's metallurgical structure undergoes transformation—from the relatively soft austenite retained from heat treating into the much harder, tougher, fatigue resisting property, martensite. The result is a stabilized bearing that permanently holds it precise tolerances and assures the lowest possible coefficient of friction no matter how severe or varied the operating temperatures may be.

We call this the "cold war" against friction—one of the many advanced ways and reasons Aetna consistently produces anti-friction products that lead the field in dependability and cost-cutting efficiency.

Perhaps stabilization can solve a stubborn bearing application problem for you, too. Aetna's technical staff is ready to help you investigate. Why not outline your problem for their study?

Aetna

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Perspectives

IN DESIGN AND DEVELOPMENT

HOW NOT TO RECRUIT ENGINEERS

June was graduation month for many engineering students, but finding a job was no problem for them—they had been signed up months before, some in their Junior year. Others have been on half pay since March, if they agreed to join a certain company upon graduation—and still more will receive a $700 bonus just for signing up with a company. These are just a few of the lures held out to engineering students, and according to Chester Linsky, (right) Assistant Professor of Industrial Engineering, at Pennsylvania State University, the companies are dead wrong in their approach to the competitive game of recruiting engineers.

The companies should be made to realize that they are poisoning the minds of the students by bribing them with high salaries, and are putting them in a position to say that they will be getting more money upon graduation than their professors earn. Today too many students feel that their degrees are up for sale, and all they must do is graduate. After a while, learning gets to be of secondary importance. College faculties then have the additional job of educating the student to consider first what kind of future he can expect to have with a company, rather than how much he can get from the highest bidder.

ABOUT THE RECRUITERS

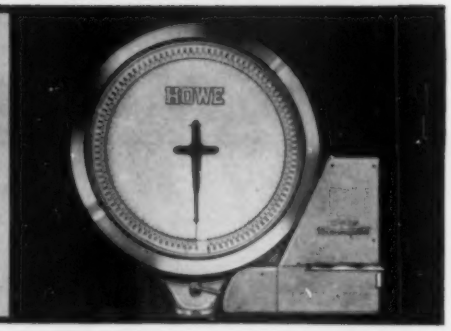
Too many times the company sends the wrong person to recruit. Frequently it is someone from the personnel department; once even a recreation director from a company arrived on campus to hire engineers. In another instance, a representative of one division of a corporation was sent out to recruit engineers for the entire corporation. Such an arrangement prevents students from asking specific questions about a plant or its engineering department operation. This is an excellent example of the charge that most companies actually do not know what they want in terms of engineering help. In many cases this "mass hiring" only leads to "mass weeding-out" and firing at the end of the training period.

THE RECRUITER MUST GET SOMEBODY

Another reason for the "bribery" approach to hiring engineers is that the person sent out to do the recruiting feels that he must bring back somebody. Professor Linsky is of the opinion that these recruiters do not spend enough time with the students, either to determine if they have the exact qualifications the company desires, or explaining the advantages to be found in the company other than pay and fringe benefits. It is not uncommon to see professors "wined and dined" in hopes that they will recommend a particular company highly to their students.

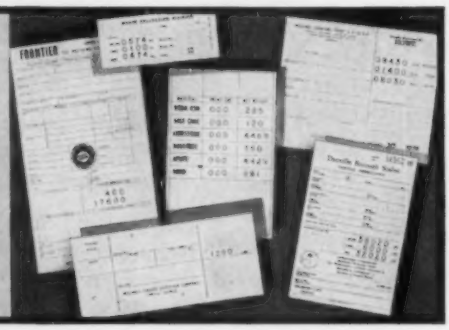
(Continued on page 131)

Why Bodine motors were selected for Howe Scales

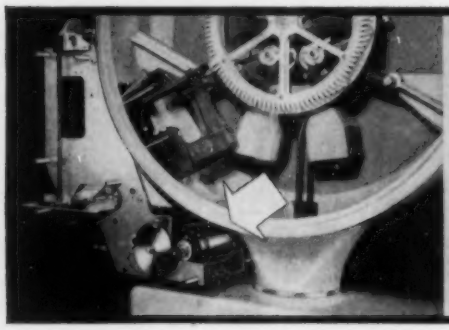


1 This is a two-in-one piece of equipment. It weighs a load and simultaneously records the weight.

2 A combination of a Howe Mechanoprint and a Tape Drive Dial, it's used for industrial applications such as weighing loaded trucks.



3 With the load in place, you press a bar, and the weight is automatically printed on a tape, ticket or form.



4 The printing mechanism of the Howe Mechanoprint is operated by this Bodine Type NSI-13, 1/40 fractional horsepower motor.

5 Manager of the Electrical Products Division of the Howe Scale Company is Mr. John S. Blackwell.

"The weight printing mechanisms of all Howe Mechanoprints are operated by Bodine Motors. We require a motor of highest quality and dependability, a motor able to withstand the abuse of frequent, intermittent service under all conditions. Bodine Motors have proved themselves to be entirely satisfactory in all respects. We are well pleased with their performance."

BODINE

BODINE

fractional horsepower

MOTORS

6 Mr. Blackwell answers the question, "Why Bodine Motors?" with some real good "reasons why"...see above.

7 Be sure your motor is as good as your product. Contact Bodine Electric Co., 2260 W. Ohio St., Chicago...or check your Sweet's file.

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voltage regulators
x-ray timers
traffic signal timers
stirrers
calculating machines
envelope sealers
diesel governors

. . . and for many other applications.

Ask for a sample copy of 'The Motorgram,' a bi-monthly publication discussing the application and design of fractional horsepower electric motors.

Perspectives

WHAT CAN BE DONE

Too many applicants are not screened properly to determine whether they meet the company's needs. Colleges should arrange a standard procedure for such interviews, so that the student will be able to meet the right people and ask and get answers to specific questions. This would help weed out unqualified candidates. One aid would be standard interviewing procedures and forms to cut down on repetition. With improved interviewing techniques, it would keep the students in class rather than taking many cuts to make "plant trips." Not much can be learned on these trips. The student is bound to have the red carpet rolled out to give him the impression that the chief engineer's job is just months away.

THE EDUCATOR AND INDUSTRY

The inadequate salaries of college professors is an old story. Take, for example, the college that offered a man $4000. He had a Masters Degree in Aeronautical Engineering and 6 years of research experience. Another was offered $5600 to be Assistant Dean of an Engineering School. He had a Masters Degree, and professional and teaching experience.

Industry can help here by making donations to specific departments in universities—not for research; rather, for a slush fund for improving the department's faculty salaries, and laboratory equipment. Donating good equipment is an essential item. Today, many colleges have antiquated junk for teaching important lab courses. Such a move would get a better grade of instruction at the under-graduate level where it is needed. Now, many of the better professors teach only at the graduate level.

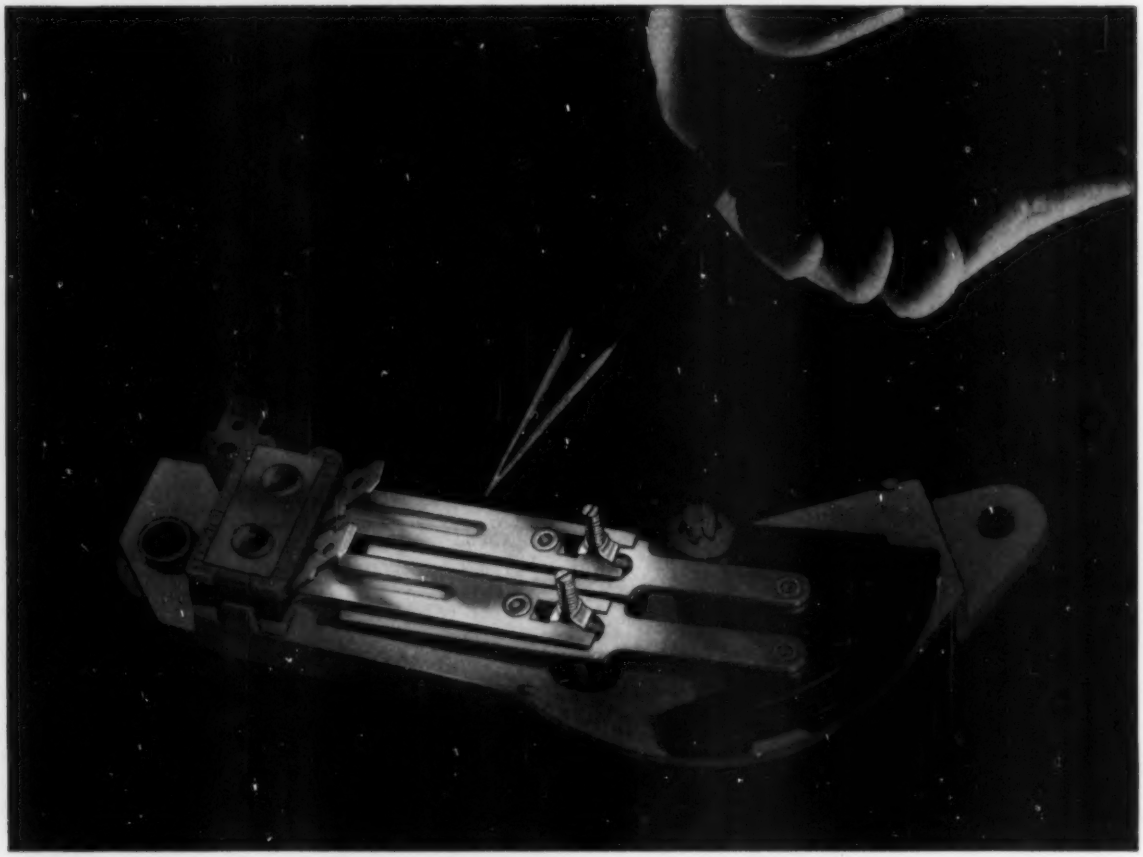
IMPROVING ENGINEERING EDUCATION

Many of the extracurricular activities should be eliminated. With the great advances being made in science, more time should be spent on these subjects rather than on the "humanities." For both the students' and industry's benefit, the colleges should pump in more quality, give stiffer assignments, and let the weak sisters fall by the wayside. In the long run the students will appreciate it when they find themselves out of a field they never should have entered in the first place.

PROFESSORS AND PART TIME WORK

A good plan in use by some companies is that of taking college professors into the engineering departments for summer work. The purpose is twofold. They earn some extra money, and are exposed to the latest in design and manufacturing techniques. This latter information is, in turn, passed on to the students. But, Professor Linsky says, while several corporations help engineering colleges this way, there are too many that take only those professors who can make money for them as consultants. Colleges could easily foil this move by discouraging companies from recruiting engineering students, if the companies did not establish a summer employment program for professors and instructors. Such a cash outlay by the company would be small indeed compared to the dividends it would pay, and to the money now spent on lavish recruitment programs.

Another program would have a professor spend one year in industry for every four he spends teaching. This would give him a chance to catch up with the latest practices and bring new, practical ideas to the classroom. Companies, likewise, should send men in to teach.



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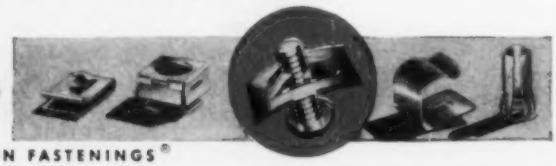

Progress is Uphill

TO ALMOST EVERYONE there comes a time when there is a parting of the ways. One branch of the fork may lead into a very inviting shady forest carpeted with pine needles, cool, alluring and fragrant. The other fork of the road may be uphill, perhaps quite steep and hot, sunny above and stony underfoot besides.

Naturally, the cool inviting forest is attractive. It is a nice place to relax, enjoy life and perhaps even doze. The going is easy, perhaps too easy. With little to do and nothing to challenge the individual, the sinews of character building and ambition get flabby.

On the hot sunny road the going will be relatively more difficult. Plodding up the hill, over the sunny ground, will be hard work. But the open air and warm sunshine do much to stimulate both mind and body. The hardships and barriers build incentives to struggle onward to ever greater heights.

It is not always easy to choose between the hard and the easy way. There certainly is no sense in blindly "going at it the hard way." But there is a great deal of sense in studying and analyzing the pros and cons of the easy way. The person who always follows the path of least resistance, in order to lead a languid lazy life, will usually end up with little or no career, little or no self-satisfaction and with a feeling of frustration in the later years of life.

Last month about twenty thousand young engineers left various campuses to enter industry. All of them faced a great temptation. Salaries offered were higher than ever. Many prospective employers offered further benefits other than money. Some offered free membership in country clubs.

Such offers may or not not be open to criticism. But when a company hires more engineers than really needed, just to have a "surplus stock" on hand, it is equivalent to offering an inviting shady forest in which to loaf. Any engineer taking a position in such a company will find that he has a position that pays him a gratifyingly high salary and other rewards but which offers him no opportunity to grow. He is compelled to learn the art of "gold bricking" instead of receiving experience in the art of engineering.

Unless a position gives the opportunity to do real engineering work, it has little or nothing to warrant the time and attention of an engineering graduate who is worthy of his degree. The easy road is nice but it is not usually conducive to growth and advancement.

It is a job candidate's market. The "pickings" are plentiful and juicy. But the situation is also fraught with dangers. The engineer who goes after the "easy pickings" or the one who has his head turned by flattering offers is in grave danger of never achieving the goal which was his objective when he entered college. He may never become an engineer because he elected to doze in the cool forest rather than to struggle onward and upward on the rough and rocky road to success.

George F. Goodrich

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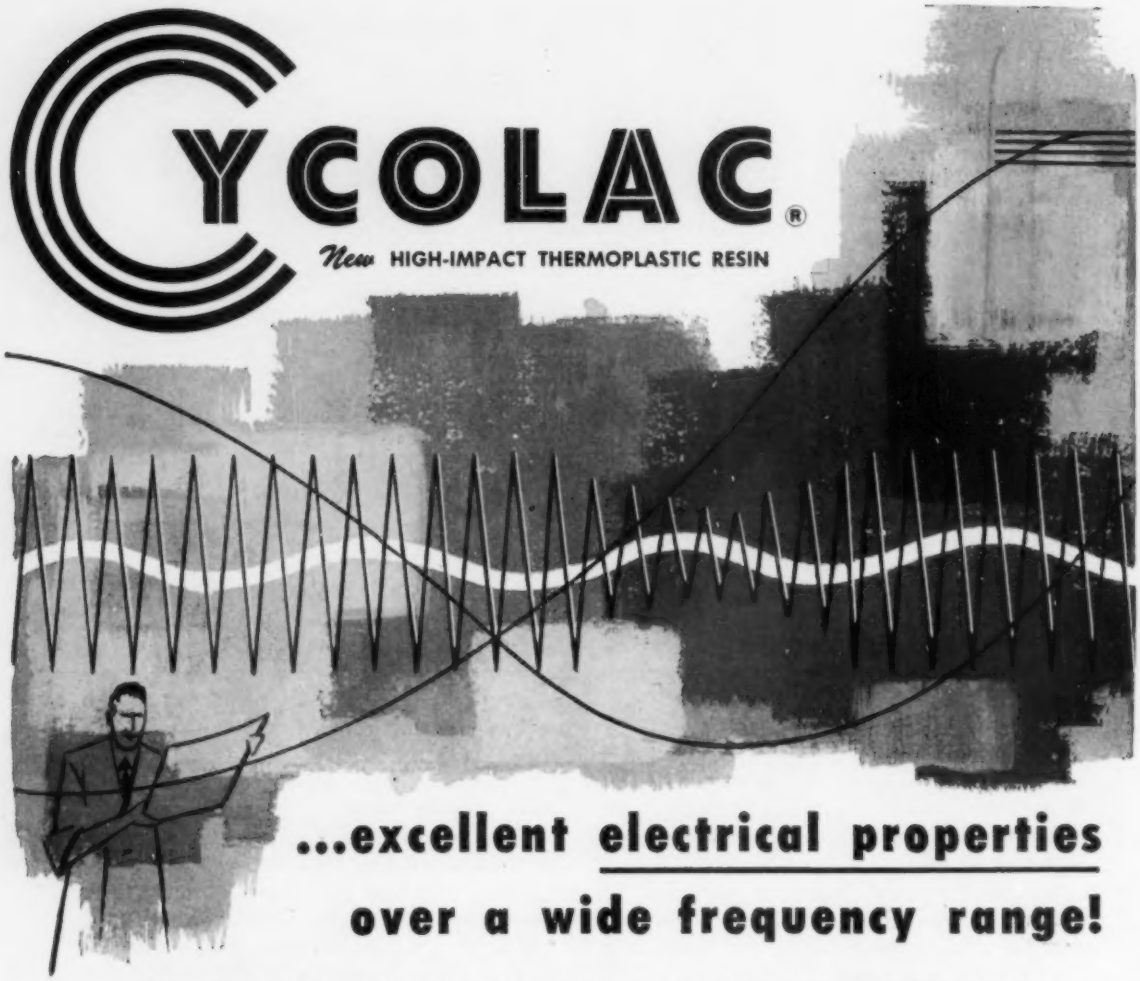
New HIGH-IMPACT THERMOPLASTIC RESIN



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MARSHALL WARD
Manager, Special Alloys Div., The H. A. Wilson Co., Union, N. J

When instruments, control devices, and precision mechanical assemblies are called on to operate within close limits of accuracy under a wide range of environment conditions, the effect of temperature on the elastic modulus may become a critical problem, particularly for highly stressed parts where load deflection is important. In such applications, a material with a low or zero temperature coefficient of modulus may reduce range of deviation, simplify design of the stressed part or reduce design complications in other parts. A new nickel-iron-chromium-titanium alloy, Ni-Span C, has the unusual property of maintaining a constant elastic modulus through a range of temperature from —50 to 150 F. The alloy can be precipitation hardened to develop high mechanical properties in combination with low hysteresis and drift. By proper control the precipitation hardening heat treatment can be varied, as

Fig. 1—Thermo-elastic coefficient can be controlled over a rather wide range by selection of hardening temperature. Curve shown is for a typical lot; position of curve to left or right along zero coefficient line depends on composition. Precise heat treating conditions are specified for each lot of material.

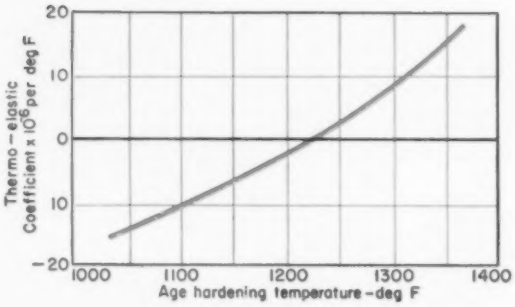
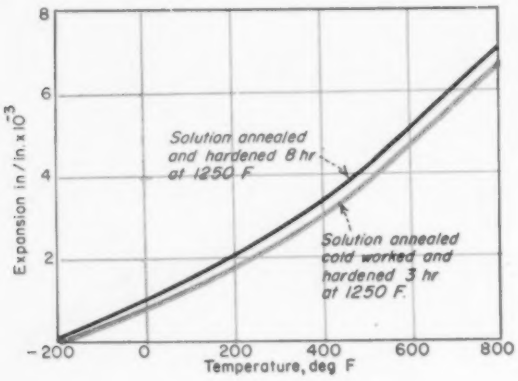


Fig. 2—Thermal expansion of Ni-Span C is moderately high; cold work prior to hardening has a slight effect on the expansion rate.



shown in Fig. 1, to give thermoelastic coefficient of any desired value near zero.

This alloy came out of an investigation of the anomalous properties of the nickel-iron series carried on by Charles Guillaume in France some 70 years ago. It was found that addition of chromium and other elements could suppress the peak positive thermoelastic coefficient which occurs at about 36 per cent nickel and bring it down to a value near zero. Further work by the International Nickel Co., in the development of age hardening nickel-iron-titanium compositions, established that the addition of chromium produced a precipitation hardening constant modulus alloy of high strength.

Deflection rate of most metals and alloys increases with temperature; in other words, the temperature coefficient of elastic modulus is negative. For some materials the modulus decreases as much as 0.03 per cent for each degree temperature rise, as shown in Table I.

While Ni-Span C can have a zero thermoelastic coefficient, it does have a moderately high coefficient of expansion, as shown in Fig. 2. Also, the degree of cold work prior to hardening has a slight effect on the expansion coefficient, and the value goes through an inflection point at about 300 F.

Mechanical hysteresis and drift are two other forms of deviation from ideal elastic behavior important in critical applications. These phenomena are sometimes confused but are actually separate problems.

Hysteresis occurs where loads on a stressed member are cycled. Deflections at the same load are different for increasing and decreasing loads. Hysteresis is an inherent property closely related to damping capacity, but can be influenced by heat treatment.

Drift is the change in deflection under a constant load with the passage of time. Drift can be minimized or eliminated as a design factor through heat treatment and other stabilizing methods.

Table I—Elastic Modulus and Change With Temperature

Material	Modulus x 10^6 psi	Change from −50 to 150 F, per cent
Ni-Span C	27	0
Carbon steel, 0.90% C	30	2.9
Stainless steel, 17% Cr	29	2.9
Alloy steel, 3½% Ni	30	3.0
Monel	26	3.3
Beryllium copper	18	3.9
18% Nickel silver	18.5	3.9
Phosphor bronze, Grade A	15	4.2
Brass, 73% Cu, 27% Zn	15	4.3
Stainless steel, 18-8	28	4.5
Invar, 36% Ni steel	21	5.4
Duralumin, heat treated	10	6.5

Table II—Relaxation Under Steady Load of 50,000 psi at Elevated Temperatures*

	Relaxation in per cent of Load Deflection, for Temperatures of					
	300	400	500	600	700	800
Music wire	11					
Spring steel, hard drawn	10					
Spring steel, oil tempered	4.5	10				
Steel, chrome vanadium	2	5	8			
Stainless, 18-8			1	6		
Stainless, 17-7 PH				0.5	4.0	
Ni-Span C				2.0	3.0	9
Inconel				0.5	3.5	
Inconel X					0.1	7

*Data from Hunter Spring Co., Lansdale, Pa.

APPLICATIONS

Major applications for Ni-Span C are for stressed members where relative changes in deflection due to temperature variation must be avoided: helical and flat springs, Belleville washers, diaphragms, bellows, Bourdon tubes, torsion bars or other elastically loaded members. Inherent

Table III—Composition Specification

Nickel	41 to 43 per cent
Chromium	4.9 to 5.5 per cent
Titanium	2.2 to 2.6 per cent
Carbon	0.06 max
Manganese	0.80 max
Silicon	1.00 max
Aluminum	0.30 to 0.80 per cent
Sulfur	0.04 max
Phosphorus	0.04 max
Iron	Balance

Table IV—Physical Properties of Constant Modulus Alloy

Melting Range	2650 to 2700 F	
Density	0.294 lb/cu in.	
Specific Gravity	8.15 gm/cc	
Specific Heat, 32 to 212 F	0.12 BTU/lb/F	
Thermal Expansion Coefficient −50 to +150 F	4.5 x 10 $^{-6}$ F	
Thermal Conductivity, 32 to 212 F	90 BTU/sq ft/F/in./hr	
	Soft Annealed	Fully Aged*
Thermal Coefficient of Resistivity, per deg F	0.00025	0.00031
Electrical Resistivity, ohms/sq mil/ft at 68 F	580	480
Electrical Conductivity, % IACS at 68 F	1.4	1.7
Modulus of Elasticity, psi x 10^6	24	27.5
Modulus of Rigidity, psi x 10^6	9.4	9.8
Thermoelastic Coefficient, x 10^{-6} per deg F	−35 to −15	−10 to +10
Tensile Strength, psi	90,000	200,000
Yield Strength, 0.2% offset, psi	35,000	180,000
Proportional Limit, psi	15,000	110,000
Elongation, % in 2 in.	40	7
Brinell Hardness	125	395
Rockwell Hardness	70B	42C

*For strip 50 per cent cold worked before aging. Values for wire are higher.

Table V—Typical Mechanical Properties

	With No Cold Work				With 50 per cent Cold Work			
	Before Hardening	After Heat Treatment at Temperature 1100 F	1250 F	1350 F	Before Hardening	After Heat Treatment at Temperature 1100 F	1250 F	1350 F
Tensile Strength, psi	90,000	150,000	180,000	175,000	135,000	185,000	200,000	200,000
Yield Strength, 0.2% offset psi	35,000	95,000	115,000	115,000	130 000	160 000	180.000	180,000
Proportional Limit, psi	15,000	70,000	65,000	65,000	55,000	105,000	110,000	105,000
Elongation, % in 2 in.	40	30	18	17	6	8	7	7
Rockwell Hardness	70B	23C	33C	32C	28C	39C	42C	42C
Brinell Hardness	125	245	305	300	270	360	395	395
Modulus of Elasticity, x 10^6 psi	24	27	26.5	26.5	25.5	27.5	27	27

temperature compensation offered by this new material will often make it possible to simplify structures and linkages, and even eliminate compensating means. Within the range of −50 to 150 F, the change in modulus for Ni-Span C is a very small fraction of that in other alloys. The temperature range can be widened to −90 and 240 F with only a small increase in temperature effect.

Two factors limit its use in some applications: low electrical conductivity, and poor thermal conductivity; both are of a very low order. For a flat spring in an electrical circuit the use of Ni-Span C normally would require a copper shunt. However, the thickness of the shunt can be small as compared to the blade thickness, and the Ni-Span C part can be heat treated to develop a positive thermoelastic coefficient which will compensate for the negative coefficient of the shunt. Such a combination would have a much lower variation of stiffness with temperature change than any of the usual current carrying metals.

At temperatures substantially higher than those of the constant modulus range (above 300 F) Ni-Span C has good resistance to relaxation, as shown in Table II based on tests made on compression springs. Wire for the Ni-Span C springs was cold worked 94 per cent; slightly better results might be obtained with wire having a lower amount of cold work.

SPECIFICATIONS

Ni-Span C is produced to the composition limits shown in Table III. Physical and mechanical properties are listed in Tables IV and V. Mechanical properties shown in the table are average values for 0.050 in. strip, and are comparable to alloy steels. Specifications issued covering this alloy are:

No. 5221 Alloy Strip, Solution Treated
No. 5223 Alloy Strip, Cold Rolled, 10 per cent Reduction
No. 5225 Alloy Strip, Cold Rolled, 50 per cent Reduction

As a finished product it is available in strip, wire, cold drawn rod, hot finished rod, hot and cold finished flats

and forgings. Strip is usually furnished in a range of cold reduction, the amount depending on forming operations. Full hard temper has 50 per cent cold reduction; in this condition it can take only slight bending.

For corrugated diaphragms strip is supplied with from 5 to about 25 per cent cold work. Temper, depth of corrugation and strip thickness present conflicting requirements and have to be balanced for each design. For diaphragms strip is available from 0.002 in. to any useful thickness; most applications range from 0.002 to 0.010 in.

Best mechanical properties and minimum hysteresis and drift in the finished diaphragm are generally obtained with maximum cold work, but the permissible amount of cold work decreases with thinner material. Maximum degree of cold work for usual design is:

Thickness, in.	Max. Cold Work, per cent
0.002	annealed
0.003-0.0038	5 to 6
0.004	10
0.005	15

Diaphragms can be formed from strip cold worked 25 per cent with a two-stage forming operation when the design permits. For coil springs wire is usually specified with 65 to 90 per cent cold work. Wire is available in diameters from 0.002 to 0.350 in. with ASTM music wire tolerances on diameter. For automatic spring coiling, wire down to 0.115 in. dia is furnished with a lead coating; below 0.115 in. a copper coating is used. The wire presents no unusual problems in spring manufacture. Uncoated wire can be coiled on a mandrel, and coated wire operates normally in automatic coilers. Flat wire with either square or round edges is available in a reasonable size range.

Other shapes can be supplied where design conditions require. Cold drawn rod is available for straight parts of larger diameter, usually finished with 25 to 35 per cent cold reduction which gives close to maximum properties after age hardening. Above 1¾ in. dia it is necessary to use either hot-finished rod, or forgings if quantities are small. These heavy shapes are furnished only in the solution annealed condition; with lower mechanical properties after heat treatment lower working stresses and heavier sections must be used.

Watch, clock and instrument hairsprings can be made of Ni-Span C. In watches and clocks the constant modulus is an aid to accurate time keeping; when used as an instrument spring, the low hysteresis and minimum drift properties improve accuracy of calibration. These advantages also apply to any mechanism where a spring member is used as a part of timing system.

DESIGN STRESSES

For coil springs working stresses can be given in per cent of tensile strength:

Type of Spring	Percent of Tensile Strength
Extension	30 to 35
Compression	38 to 42
Torsion	65 to 70

Ratio of torsional proportional limit to ultimate tensile strength is 38 to 42 per cent for most room temperature applications. While it has not been advocated as an elevated temperature spring material, it can be used at temperatures up to 650 or 700 F, with working stresses of 40,000 to 50,000 psi for otherwise ordinary service conditions.

HEAT TREATMENT

Two heat treatments are required to obtain the desired physical and mechanical properties. The first one is a solution anneal ordinarily performed by the material supplier. The second or precipitation hardening heat treatment must be performed after forming operations by the user, and complete heat treating instructions are supplied with the material.

For any specific part the heat treatment for maximum properties depends on the degree of cold work as shown in Fig. 3. Where cold work throughout the part is not uniform, hardening will take place first in the areas subjected to maximum cold work. In a diaphragm, for example, the cold work will be maximum at the crest and trough of each corrugation shading to something less in the sides. If a diaphragm in this condition is heat treated, the areas with the highest cold work will harden first; areas with lesser cold work will then harden setting up residual stresses which will cause abnormal hysteresis and drift. To prevent this condition, parts are stress relieved prior to precipitation hardening by holding for 3 or 4 hr at about 750 F. This may be followed immediately by the age hardening heat treatment. A 3 hr soak is sufficient for parts made from solution annealed strip; 4 hr should be used with parts made from cold worked strip.

Where precision requirements justify, these additional stabilizing treatments may be given subsequent to age hardening:

Exercise. Parts are cycled at a deflection about 10 per cent greater than that expected in service. About 30 min at 30 cycles per min is usually sufficient.

Thermal Shock. Alternate immersion in a solution of dry ice and acetone, and boiling water. About 8 complete cycles is sufficient, allowing enough time in each case for the parts to come to the temperature of the liquid.

While these recommendations apply specifically to diaphragms, the same general approach is used for coil springs and similar parts requiring maximum accuracy of performance.

HARDENING ATMOSPHERE

Because Ni-Span C oxidizes readily at the heat treating temperature of 1100 to 1350 F, hardening must be carried out in a non-oxidizing atmosphere. Best results are obtained in a vacuum furnace with an absolute pressure of 10^{-4} or 10^{-5} mm Hg. Under these conditions parts will come out of the furnace in a bright condition and can be joined by welding without a cleaning operation. Parts heat treated in this manner can be silver soldered without cleaning using fluxes containing fluorides, while a mild cleaning is necessary for soft soldering. If production quantities justify this type of equipment, it will produce

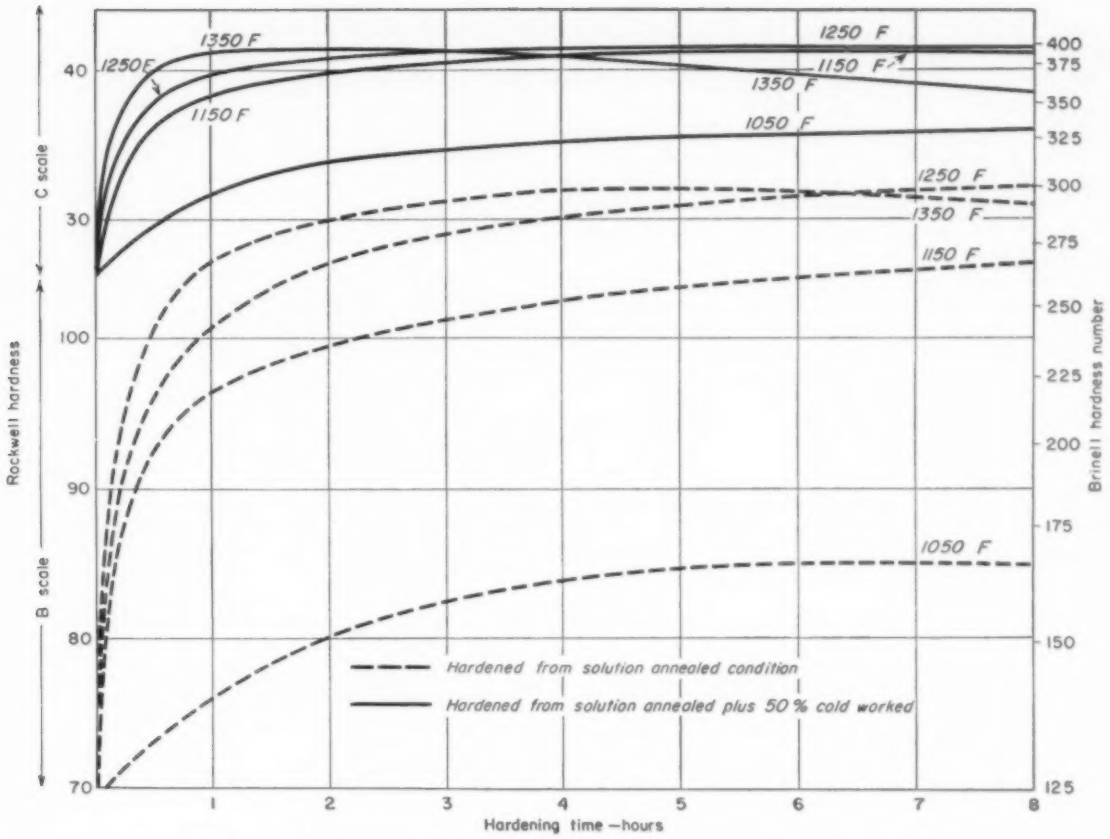


Fig. 3—Rate of hardening at various temperatures for both annealed and 50 per cent cold worked material. Note that higher temperatures give much faster hardening as well as higher strength. Hardening rate for intermediate amounts of cold work, or for parts having varying degrees of cold work are between the two extremes shown. When requirements for a specific modulus coefficient and maximum hardness are in conflict, the optimum hardening time and temperature will depend on the specific application.

good work with very little handling subsequent to age hardening.

Neutral atmosphere furnaces can also be used, with dry hydrogen, dissociated ammonia, helium or argon. It is essential that the atmosphere be as dry as possible; use of an activated alumina dryer is recommended not only to remove moisture but for a dissociated ammonia atmosphere it will keep residual ammonia at a low value.

Where such atmospheres are used the best results can generally be obtained through the use of a retort rather than a batch-type furnace. The retort or container, usually with a bolted-on cover and equipped with inlet and outlet tubes for atmosphere, is loaded, closed, purged, and filled with the atmosphere before placing it in an ordinary muffle furnace.

In a batch furnace a controlled atmosphere is maintained in both a heating chamber and a cooling chamber. Work is usually carried through in open pans or shallow boxes. At each opening of the doors the furnace atmosphere is subject to some change both in dew point and oxygen content. Where parts are given a stress relief anneal followed by precipitation hardening, the production from a retort will be nearly the same as a batch furnace but with better control of the atmosphere.

Distortion in heat treatment is negligible and it is not necessary to place the parts in fixtures. Diaphragms should be placed in a rack giving two or three point support, and springs should be arranged so that no one part is carrying the weight of several others. After precipitation hardening is completed, the parts are allowed to cool to 400 F or lower before exposure to air. The cooling rate is not important and a fan can be turned on a retort after it is removed from the furnace. A batch-type furnace should have a cooling chamber following the heating zone. In locating parts within a retort or other type of container the atmosphere should completely surround each part. A tangled mass of springs, or diaphragms which nest within each other should be avoided.

Furnace temperature control should be good but does not call for extreme precision. The temperature required depends on the composition of the batch and the thermoelastic coefficient wanted. Control within plus or minus 10 F is sufficiently accurate for most cases.

Hardening temperature selected determines the thermo-

elastic coefficient; time at temperature controls the hardness and strength, and varies with the degree of cold work. Heat treating temperatures in the higher ranges require much shorter times to reach optimum properties. As shown in Fig. 3, for material cold worked 50 per cent and hardened at 1350 F, peak properties are obtained in 2½ hr; for solution annealed material the time is about 4½ hr. Wire for coil springs is usually supplied with more than 50 per cent cold work, and the hardening time is reduced as much as half.

Optimum heat treatment thus depends on the best compromise between usually conflicting requirements of modulus coefficient, working stress and heat-treating cost. Each shipment of material includes instructions for heat treatment with suggested temperatures for zero modulus coefficient and maximum properties.

CLEANING

Removal of a badly oxidized surface presents some difficulties; efforts applied in avoiding surface oxide are rewarding. To remove moderate oxidation the following solution can be used as a pickling bath:

Potassium Dichromate	10 grams
Sodium Fluoride	7 grams
Sulfuric Acid (conc.)	23 cc
Water to make	100 cc

The salts should be dissolved in water and acid added. The solution should be allowed to cool before using and should only be used at room temperature as its activity increases markedly with a small rise in temperature. It should be mixed, stored and used in a plastic container or lead-lined tank (never in glass). Two or three minutes immersion is usually sufficient to permit washing off the oxide in running water or removing it with a mild brushing or wiping. Parts should be thoroughly rinsed in water and neutralized in an alkaline bath.

Where oxidation is severe it is sometimes practical to remove the worst of the coating by shot peening, or tumbling if the parts are substantial enough. Shot peening is effective with compression springs and ordinarily no further cleaning is necessary as a bright finish is seldom required on such parts. Tumbling works well with Bourdon tube C-shapes and can be followed by treatment with the pickling solution described above. A tumbling operation as a preliminary to pickling, while not essential, is beneficial for diaphragms. For each type of part the work load, type and amount of abrasive, and barrel speed must be developed. A long-time, slow-speed tumbling gives parts a mild peening with consequent improvement in the elastic properties; complete removal of internal stresses can be obtained in about 72 hr.

MACHINING

A reasonable amount of patience coupled with a proper choice of tools and lubricants will produce satisfactory machining with no more difficulty than is ordinarily experienced with the nickel-chromium alloys. Light feeds and slow speeds should be used. With tungsten carbide tools a water soluble oil should be used as a coolant, and with high speed steel a sulfur-base oil. The flow of coolant or lubricant should be ample in any case to prevent surface checking. The same general instructions apply to grinding; the wheel should be silicon carbide, vitrified bonded of medium to soft grade and open structure, having about no. 46 grit. An ample flow of coolant should be used, made as a lean mixture of water and soluble oil, about 35 to 1.

JOINING

Ni-Span C can be joined by welding, silver brazing and soft soldering. Welding methods include Heliarc, resistance and condenser discharge welding. About the only precaution needed is to keep the alloy clean to minimize oxide inclusions in the weld.

An important requirement in silver soldering is uniform heating of the part to avoid possible cracking. Induction heating is satisfactory; if torch brazing must be used the flame should be kept on the mating part and the Ni-Span C heated by conduction. Resistance brazing works out well and produces strong, pressure-tight joints. Ni-Span C can be silver brazed after age hardening without loss of properties if exposure to 1400 F is kept under half a minute. A silver solder having a flow point of 1185 F used with commercially available fluxes will make satisfactory joints.

When soft soldering is employed, the surface should be in the cleanest possible condition. Joints should be made by first tinning the surfaces and then sweating them together. Any good flux may be used, the surfaces being cleaned afterward and, if necessary, neutralized. Rosin and alcohol flux may be used for sweating such surfaces together where possibility of corrosion must be avoided.

CORROSION RESISTANCE

Nickel content of Ni-Span C is 42 per cent and the chromium content averages 5.2 per cent which keeps it out of a stainless classification. However, the alloy does resist industrial atmospheres in a satisfactory manner—the only claim for corrosion resistance made for it. This includes highly humid atmospheres so long as condensation does not take place and water is not allowed to remain on the material.

Ni-Span C has been tested against sea water immersion and also exposure to the atmosphere 800 ft from the ocean. Under immersion a specimen $\frac{1}{16}$ in. thick pitted through in 6 months. In the sea atmosphere test the results were satisfactory, the loss of weight being of a low order.

MAGNETOSTRICTION

Another group of applications in which Ni-Span C has proved useful on an experimental basis is as a magnetostrictive component. So far the alloy has only been used in production on tuning forks, vibrating needs, electromechanical bandpass filters and resonators. In such applications the constant modulus property shows up as a constant temperature coefficient of frequency. More detailed data is waiting on the completion of further tests.

EDITOR'S NOTE—Other recent articles on special-purpose materials are listed on page 202.

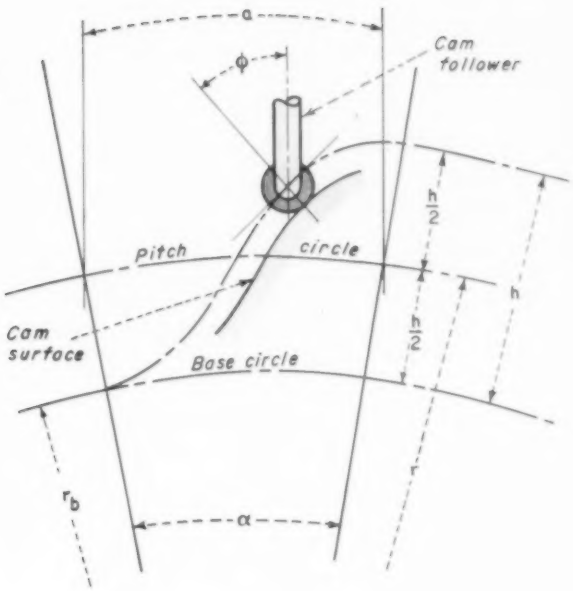


Fig. 1—Geometric relationship of cam variables.

Minimum Cam Size as determined by pressure angle

Formulas, tables and nomogram for selecting size of cam to keep pressure angle under a specified value.

ALBERT E. SANDERSON
Associate Professor, Northeastern University

SYMBOLS

a	arc length along pitch circle
f	cam factor
h	rise of follower
r	pitch circle radius
r_b	base circle radius
α	phase angle
ϕ	pressure angle

IT IS GENERALLY RECOGNIZED that large pressure angles in cams are not desirable. The pressure angle ϕ, as illustrated in Fig. 1, influences the efficiency with which a driving force is transferred from the cam to the follower. An increase in pressure angle results in:

1. Increase in side thrust against follower causing a bending moment.
2. Increase in friction and wear on follower, roller and cam surfaces.
3. Decrease in direct or useful force on direction of follower centerline.

Pressure angle can be decreased by increasing the pitch circle radius, and therefore the cam size. However, because space is usually at a premium, it is more practical to determine the maximum permissible pressure angle and select the cam size so that the angle is not exceeded.

Cam Factors

To quickly determine cam pressure angles, the ratio of the arc length a along the pitch circle to the total rise h is designated as the cam factor f:

$$f = a/h \tag{1}$$

However, the relationship between the arc length and the pitch circle radius r is:

$$a = \frac{2\pi r\alpha}{360} = \frac{r\alpha}{57.3} \tag{2}$$

Combining Eqs (1) and (2) and rearranging terms, r becomes a function of f:

$$r = \frac{57.3hf}{\alpha} \tag{3}$$

The cam factor will vary for each type of cam motion (such as parabolic, uniform) and can be written as a function of the pressure angle. For example, the cam factor for uniform motion as shown in the cam diagram in Fig. 2 (A) is:

$$f = a/h$$

But $$a = h \cot \phi \tag{4}$$

Therefore $$= \cot \phi \tag{5}$$

Cam factors for common cam motions are shown in Figs. 2 (B) to (D); Table I gives tabulated values as a function of pressure angle, and the nomogram in Fig. 3 solves Eq (3).

How to Apply This Method

EXAMPLE I–Motion desired: harmonic. Given: $\phi = 20$ deg max, $a = 90$ deg, $h = 2$ in.

Solution–From Table I: $f = 4.33$. Draw line on nomogram from $h = 2$ to $f = 4.33$ locating point A. Draw line from $a = 90$ through point A to the f scale. Read $r = 5.5$ in. A pitch circle radius smaller than 5.5 in. results in a pressure angle greater than 20 deg.

Table I—Cam Factors

Motion	Pressure angle ϕ, deg.						
	10	15	20	25	30	35	40
Uniform	5.67	3.73	2.75	2.14	1.73	1.43	1.19
Modified	5.85	4.00	3.10	2.59	2.27	2.06	1.92
Harmonic	8.91	5.87	4.33	3.36	2.72	2.25	1.87
Parabolic	11.33	7.46	5.50	4.28	3.45	2.86	2.38

EXAMPLE II–For multi-phase cams having two or more types of motion, calculate the pitch circle radius for each phase, convert to a base circle radius and let the size of cam be governed by the largest base circle radius. For example, a cam is to be designed to the following phase specifications with $\phi_{max} = 30$ deg, as illustrated in Fig. 4:

1. Rise 4 in. with 45 deg harmonic motion
2. Dwell 90 deg
3. Rise 4 in. with 45 deg parabolic motion
4. Drop 2 in. with 45 deg harmonic motion
5. Dwell 45 deg
6. Drop 6 in. with 90 deg parabolic motion

Solution. Pitch radii are determined from the nomogram in Fig. 3 and base circle radii calculated by subtracting total rise in each phase:

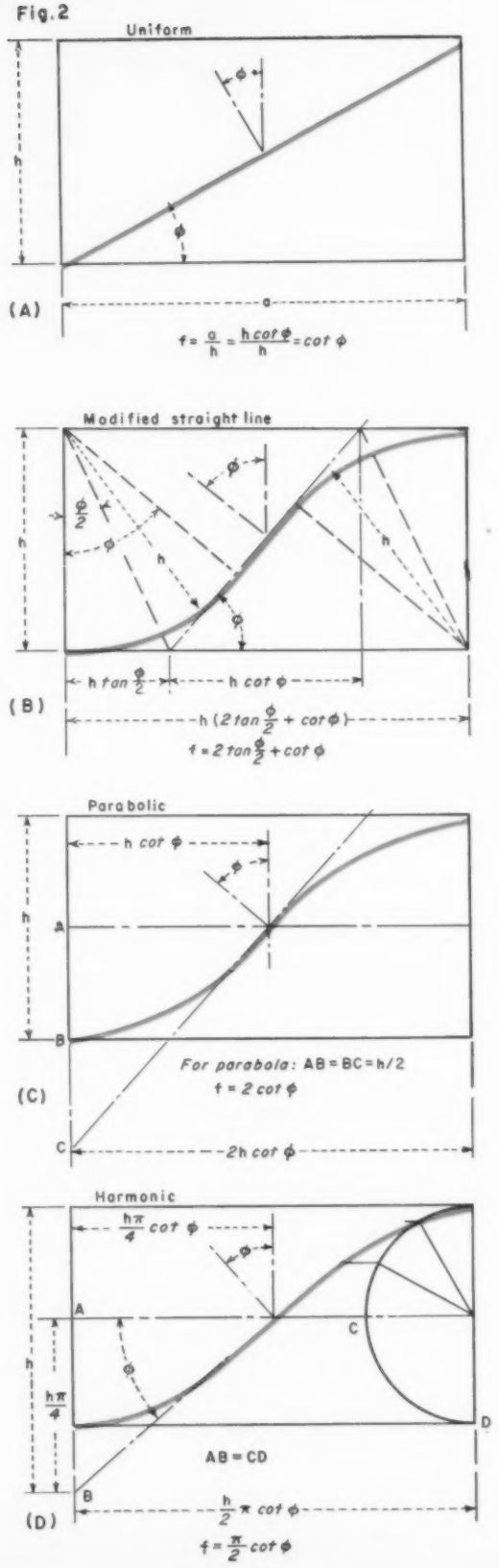
PITCH RADII	BASE RADII
1. $r = 14.0$ in.	$r_b = 14.0 - 2.0 = 12.0$ in.
3. $r = 17.6$ in.	$r_b = 17.6 - 6.0 = 11.6$ in.
4. $r = 5.8$ in.	$r_b = 5.8 - 7.0 =$ imaginary
6. $r = 13.3$ in.	$r_b = 13.3 - 3.0 = 10.3$ in.

Although $r_{max} = 17.6$ in., the maximum base circle radius is 12.0 in. which governs the size of cam. A base circle radius smaller than 12 in. will cause a pressure angle greater than 30 deg during the first phase.

The cam can now be constructed by laying out a base circle with a radius of 12 in. Ordinates from the cam diagram in Fig. 4 (if drawn to scale) are then plotted along radial divisions of the base circle.

The nomogram is also useful for determining maximum pressure angle of any phase once the geometry of the cam is fixed.

Fig. 2



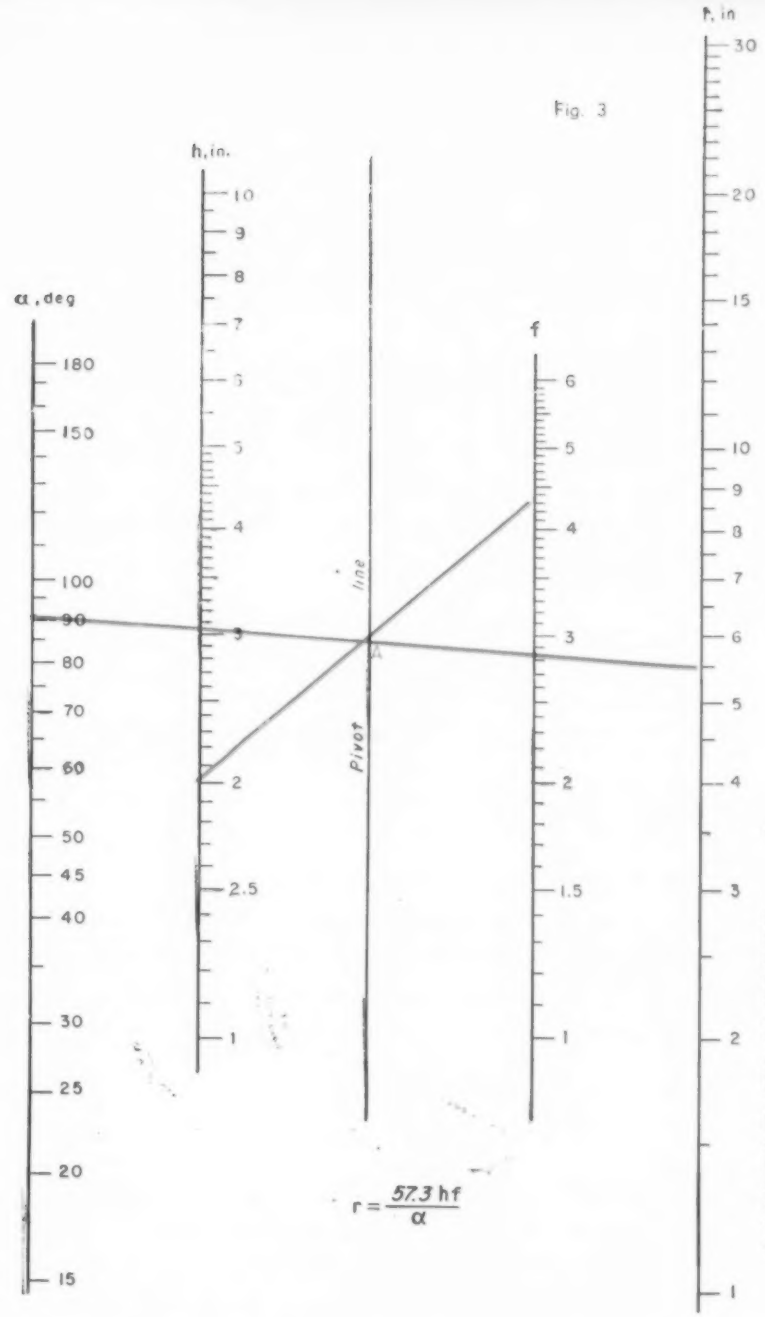


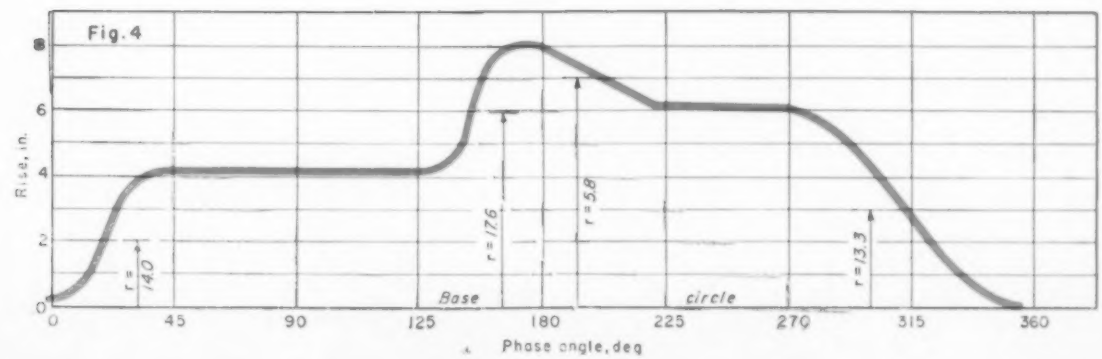
Fig. 2—Derivation of cam factors for common types of motion.

Fig. 3—Nomogram for determining pitch circle radii of cams. Line drawn through two known variables locates point *A*; line through point *A* and third variable gives value of unknown variable.

Fig. 4—Cam diagram for Example II. The minimum allowable radius *r* must be calculated for each phase of a multiphase cam to determine the minimum base circle radius.

EDITOR'S NOTE—Recent articles in *Product Engineering*, by Kloomok and Muffley described four basic steps in plate cam design: "Emphasis on Dynamic Effects," February 1955 page 156; "Pressure Angle Analysis," May 1955 page 155; "Radius of Curvature," September 1955 page 186; and "Evaluating Dynamic Loads," January 1956 page 178.

The problem of "When Will a Cam Follower Jump" was analyzed by Baratta and Bluhm in *Product Engineering*, July 1954 page 156. The article shows the relationship between profile, flexibility, mass, rotating speed and the point where a follower will leave the surface of the cam.



Designing

Strain Gage Circuits

For Sensitivity and Linearity

Comparison of bridge and potentiometer strain gage circuits; significance of sensitivity ratings and design for maximum sensitivity; determination of nonlinearity of response.

PETER K. STEIN
Instructor, Mechanical Engineering Dept., Massachusetts Institute of Technology

POTENTIOMETER AND THE WHEATSTONE BRIDGE are the two principal types of circuits used for resistance strain-gage measurements. The basic difference between these circuit, is shown at (A) in Fig. 11. It consists of a dc output voltage under zero strain, whereas the potentiometer produces a relatively large static voltage under these same conditions. Although the Wheatstone bridge is the most popular circuit the potentiometer circuit has, for some applications, substantial advantages which have to date been neglected.

The potentiometer circuit, also called ballast or series circuit, is shown at (A) in Fig. 1. It consists of a dc supply voltage applied across series resistors R_1 and R_2, one or both of which may be strain gages. Current I flows through R_1 and R_2. The static output voltage E appears across R_2 and (see reference 1 at end of article) is:

$$E = V\left(\frac{R_2}{R_1 + R_2}\right) \tag{1}$$

Defining:

$$A = \frac{R_1}{R_2} \tag{2}$$

the change in output voltage ΔE in E created by small resistance changes ΔR_1 and ΔR_2 in R_1 and R_2, is:

$$\Delta E = V\left[\frac{A}{(1+A)^2}\right]\left(\frac{\Delta R_2}{R_2} - \frac{\Delta R_1}{R_1}\right)\left[1 - \frac{1}{1 + \frac{1+A}{\left(\frac{\Delta R_2}{R_2} + A\,\frac{\Delta R_1}{R_1}\right)}}\right] \tag{3}$$

or:

$$E = V\left[\frac{A}{(1+A)^2}\right]\left(\frac{\Delta R_2}{R_2} - \frac{\Delta R_1}{R_1}\right)(1 - N) \tag{4}$$

where N is the nonlinear decrease in circuit sensitivity per unit increase in strain, and for the potentiometer circuit is equal to:

$$N = \frac{1}{1 + \frac{1+A}{\left(\frac{\Delta R_2}{R_2} + A\,\frac{\Delta R_1}{R_1}\right)}} \tag{5}$$

The Wheatstone bridge circuit is shown at (B) in Fig. 1, and is redrawn in (C) as two parallel potentiometer circuits.

Voltage output of the bridge without strain is:

$$E = \frac{(R_2 R_4 - R_1 R_3)}{(R_1 + R_2)(R_3 + R_4)} \tag{6}$$

Voltage output with strain is:

$$\Delta E = V\left[\frac{A}{(1+A)^2}\right]\left(\frac{\Delta R_2}{R_2} - \frac{\Delta R_1}{R_1}\right)(1 - N) + V\left[\frac{A_1}{(1+A_1)^2}\right]\left(\frac{\Delta R_4}{R_4} - \frac{\Delta R_3}{R_3}\right)(1 - N_1) \tag{7}$$

where N assumes the value shown in Eq (5), and A is equal to R_1/R_2, from Eq (2).

Also

$$N_1 = \frac{1}{1 + \left(\frac{A_1 + 1}{\frac{\Delta R_3}{R_3} + A_1\frac{\Delta R_4}{R_4}}\right)} \tag{8}$$

and

$$A_1 = \frac{R_4}{R_3}$$

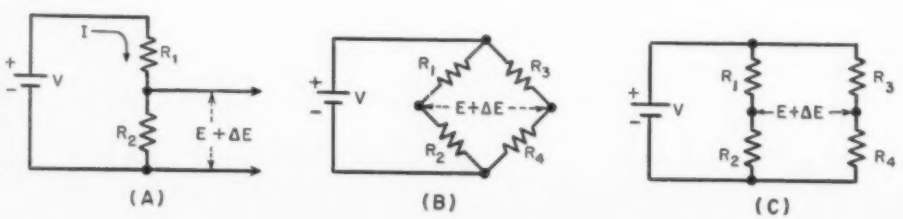


Fig. 1—Two most widely used circuits for strain gage measurements: (A) potentiometer circuit; (B) Wheatstone Bridge circuit. Bridge circuit rearranged (C) as two parallel potentiometer circuits.

NOMENCLATURE

$R_{1,2,3,4,G}$	Resistances or strain gages in a Wheatstone bridge or potentiometer circuit.
$\Delta R_{1,2,3,4,G}$	Strain-induced incremental resistance changes in $R_{1,2,3,4,G}$.
E	Steady strain-gage circuit output voltage.
ΔE	Strain-induced incremental output voltage from strain-gage circuit.
I	Strain gage current.
A	Resistance ratio R_1/R_2.
S_R	Resistive sensitivity.
S_S	Strain sensitivity.
S_T	Transducer sensitivity.
$(GF)_{1,2,3,4,G}$	Gage factor of gages 1, 2, 3, 4 or G.
N	Deviation of circuit sensitivity from linearity.
η	Circuit efficiency.
$\Sigma\left(\frac{\Delta R}{R}\right)$	Combined linear resistance changes of several gages defined in each case.

Eq (7) defines the incremental bridge output voltage ΔE resulting from small resistance changes in all four arms. In these computations the quantities are assumed large enough so as to create first order effects; second order effects have been neglected. Similarities between Eqs (7) and (3) indicate that the Wheatstone bridge may be analyzed as two potentiometer circuits, as shown at (C).

If the bridge is balanced under zero-strain conditions,

$$R_1 R_3 = R_2 R_4 \tag{9}$$

and:

$$E = V\left[\frac{A}{(1+A)^2}\right]\left(\frac{\Delta R_1}{R_1} - \frac{\Delta R_2}{R_2} + \frac{\Delta R_3}{R_3} - \frac{\Delta R_4}{R_4}\right)(1 - N_3) \tag{10}$$

where:

$$N_3 = \frac{1}{1 + \dfrac{A+1}{\left(A\dfrac{\Delta R_1}{R_1} + A\dfrac{\Delta R_4}{R_4} + \dfrac{\Delta R_2}{R_2}\right)}} \tag{11}$$

SENSITIVITY RATINGS

The sensitivity of strain gages can be expressed as resistive sensitivity S_R, which pertains to the gage itself, or as transducing sensitivity S_T which expresses the sensitivity of the circuit with which it is used. Resistive sensitivity S_R can be defined as the ratio of the change in voltage ΔE, in microvolts, to the change in resistance in micro-ohms per ohm, or $\Delta E/(\Delta R/R)$. Since the resistance change is a reflection of the physical quantity being measured, transducing sensitivity S_T can be defined as the voltage change across the gage, in microvolts per unit of quantity measured. For example, if strain is being measured, S_T is in units of microvolts per microinch per inch.

If a calibration factor K is defined as the micro ohms per ohm resistance change in the gage produced by one unit of measured quantity, then

$$S_T = K S_R \tag{12}$$

or if strain is the quantity to be measured and the microinch per inch is the unit of strain, then:

$$K = (GF) \tag{13}$$

where (GF) is the gage factor of the strain gage. And:

$$S_T = (GF)(S_R) \tag{14}$$

SENSITIVITY RELATIONS

Providing non-linearities are negligible, which is the usual case, a basic equation for sensitivity may be derived from equation (4) or:

$$S_R = \frac{\Delta E}{\Delta R_2/R_2} = V\left[\frac{A}{(1+A)^2}\right] \tag{15}$$

It is assumed, for simplicity, that R_1 is a fixed resistor and $\Delta R_1 = 0$. If E is equal to $I R_2$, which is the voltage across gage R_2, then:

$$V = E(1 + A) \tag{16}$$

and

$$S_R = E[A/(1+A)] \tag{17}$$

Eqs (16) and (17) are the sensitivity design equations for the potentiometer circuit or for the Wheatstone bridge when resistive sensitivity is defined more broadly as:

$$S_R = \frac{\Delta E}{\sum \dfrac{\Delta R}{R}} \tag{18}$$

where, for a potentiometer circuit:

$$\sum\left(\frac{\Delta R}{R}\right) = \left(\frac{\Delta R_2}{R_2} - \frac{\Delta R_1}{R_1}\right) \tag{19}$$

and for a Wheatstone bridge:

$$\sum\left(\frac{\Delta R}{R}\right) = \frac{\Delta R_1}{R_1} - \frac{\Delta R_2}{R_2} + \frac{\Delta R_3}{R_3} - \frac{\Delta R_4}{R_4} \tag{20}$$

From Eq (17) maximum theoretical sensitivity is

$$S_{R\max} = E_{\max} = RI_{\max} \tag{21}$$

The maximum resistive sensitivity which can be obtained from either a bridge or a potentiometer circuit, as defined by a single gage R_G by equation (15), is a product of the gage resistance and the maximum current which can be passed through the gage, or:

$$S_{R\max} = R_G I_{\max} \tag{22}$$

This sensitivity is independent of circuit type or component values. However, maximum sensitivity is a theoretical value and only a percentage of $S_{R\max}$ is obtained in practice. The ratio of actual sensitivity to maximum sensitivity is called the efficiency η and is equal to:

$$\eta = \frac{A}{1+A} \tag{23}$$

When A is equal to 10, η is equal to 91 percent; values of A greater than 10 do not materially increase efficiency.

Input requirements of the measuring device following the strain-gage circuit normally establish required strain-gage circuit sensitivity.

However, a compromise must be made between desired sensitivity, maximum supply voltage, and current-carrying capacity of the gage.

STRAIN SENSITIVITY

If S_S is the strain sensitivity in microvolts circuit output per micro-inch per inch strain, then:

$$S_S = S_R \cdot (GF) \tag{24}$$

and

$$S_S = R_G \cdot (GF) \cdot I_{\max} \tag{25}$$

The product of these three fundamental gage characteristics represents maximum sensitivity.

From Eq (25) it is possible to determine maximum system sensitivity before choosing a circuit or components. For example, a cathode ray oscilloscope has a maximum vertical sensitivity of 10 mv zero-to-peak input for a 1 in. vertical deflection. A Baldwin SR-4 gage, type C-1 of approximately 350 ohms, with a gage factor of 3.25 and a 30 ma current-carrying capacity, will give a maximum sensitivity of:

$$S_{Smax} = 350 \times 3.25 \times 0.030 = 0.0341 \text{ mv}/\mu \text{ in./in.}$$

The overall system sensitivity will then be:

$$S = \frac{10 \text{ mv/in.}}{0.0341 \text{ mv}/\mu \text{ in./in.}} = 295 \text{ micro-in. per in. for each inch of vertical deflection.}$$

From this the necessary gain of a pre-amplifier to achieve any desired sensitivity can be determined.

Design for Maximum Sensitivity

The problem of design is complicated by the fact that gage current has an upper limit determined by gage heating. It is difficult to specify and identify heat-transfer rates from the gage to its surroundings. Theoretical considerations are usually based on unknown constants for various cooling conditions. Experimental results are usually limited by the range which they cover. (See references 2 and 3). In general, current can affect strain gages in two ways: First, as gage temperature rises with increased currents, gage factor decreases and instability increases. This effect occurs at current levels between 20 and 50 ma for most gages. Second, currents of more than several hundred milliamperes melt the gage filament, burn the paper base, or damage the bond. In general, flat-grid gages can be operated at higher currents than wrap-around gages under the same cooling conditions for equal gage factor decreases. The introduction of pulsing techniques (reference 4) promises higher peak currents since the gage is permitted to cool between successive pulses.

In any event the values of V, A, and S_R must be manipulated so that high sensitivity S_E is obtained with reasonable values of V at less than maximum gage current.

USE OF DESIGN CHART

The equation pair (16, 17) specify circuit design relationships. Fig. 2 is a design chart showing Eqs (17) in black lines and (16) in colored lines. Its use is described in the following example.

A potentiometer or bridge circuit is to be designed using a gage of 500 ohms with a gage factor of 3.0 and a 30 ma current-carrying capacity.

Maximum resistive sensitivity $S_{Rmax} = 500 \times 0.030 = 15$

Maximum strain sensitivity $S_{Rmax} = 15 \times 3.0 = 45$

Maximum permissible voltage across the gage $E = 500 \times 0.030 = 15$ v.

From Fig. 2, if a 100-volt supply battery is used, the intersection of the horizontal $V/10 = 10$ line with the broken $E = 15$ line gives a ratio of $A = 6$. The intersection of the vertical $A = 6$ line with the solid $E = 15$ line gives a resistive sensitivity of 12 microvolts per micro-ohm per ohm, which is 80 per cent of maximum sensitivity. If this is satisfactory, then values for the circuit will be: $V = 100$ v, $R_1 = 3000$ ohms, $R_2 = 500$ ohms. The usual equal-arm bridge operates at 50 per cent of maximum sensitivity since A is equal to 1.

TEMPERATURE COMPENSATION

Temperature-induced resistance changes in strain gages may be separated and eliminated from strain-induced resistance changes in either the potentiometer or bridge circuits. If the per cent resistance change in each gage is composed of a temperature-induced one (subscript T) as well as a strain-induced one (subscript S) the following relationships, from Eq (4), will exist:

$$\frac{\Delta R_2}{R_2} = \left[\frac{\Delta R_2}{R_2}\right]_T + \left[\frac{R_2}{R_2}\right]_S \tag{28}$$

and similarly for gage R_1. Neglecting non-linearities Eq (4) is then:

$$E = V\left[\frac{A}{(1+A)^2}\right]\left[\left(\frac{\Delta R_2}{R_2}\right)_T + \left(\frac{\Delta R_2}{R_2}\right)_S - \left(\frac{\Delta R_1}{R_1}\right)_T - \left(\frac{\Delta R_1}{R_1}\right)_S\right] \tag{29}$$

So long as gages R_1 and R_2 have identical properties, are mounted in an identical manner on the same material, and are kept at identical temperatures, the output from the potentiometer circuit will be proportional only to the difference in strains. If only one gage is subjected to strain, the other serves as a temperature compensator or dummy. Then, since:

$$\left(\frac{\Delta R_2}{R_2}\right)_T = \left(\frac{\Delta R_1}{R_1}\right)_T \tag{30}$$

$$E = V\left[\frac{A}{(1+A)^2}\right]\left[\left(\frac{\Delta R_2}{R_2}\right)_S - \left(\frac{\Delta R_1}{R_1}\right)_S\right] \tag{31}$$

In a Wheatstone bridge, from Eq (10), three conditions exist under which temperature-induced resistance changes produce zero incremental bridge output.

First, if:

$$\left(\frac{\Delta R_1}{R_1}\right)_{TA} = \left(\frac{\Delta R_2}{R_2}\right)_{TA} \text{ and } \left(\frac{\Delta R_3}{R_3}\right)_{TB} = \left(\frac{\Delta R_4}{R_4}\right)_{TB}$$

so long as gages R_1 and R_2 are at the same temperature TA, and the gages in each pair are identical, gages R_3 and R_4 may be at a different common temperature TB without affecting bridge output.

Second, if:

$$\left(\frac{\Delta R_1}{R_1}\right)_{TA} = \left(\frac{\Delta R_4}{R_4}\right)_{TA} \text{ and } \left(\frac{\Delta R_2}{R_2}\right)_{TB} = \left(\frac{\Delta R_3}{R_3}\right)_{TB}$$

so long as gages R_1 and R_4 are at the same temperature TA, gages R_2 and R_3 may be at a different common temperature TB and bridge output will remain unaffected. This method of temperature compensation depends on exact initial bridge balances; otherwise the equations used here may not be applied. Maximum error committed in using four gages manufactured with a unit tolerance m for their nominal resistance R and arranged in a bridge not otherwise balanced, will be:

$$E = \frac{1}{2} V m\left[\left(\frac{\Delta R_2}{R_2}\right)_{TA} - \left(\frac{R_1}{R_1}\right)_{TB}\right] \tag{32}$$

Since gages R_1 and R_2 are at different temperatures, the bridge output is a finite quantity.

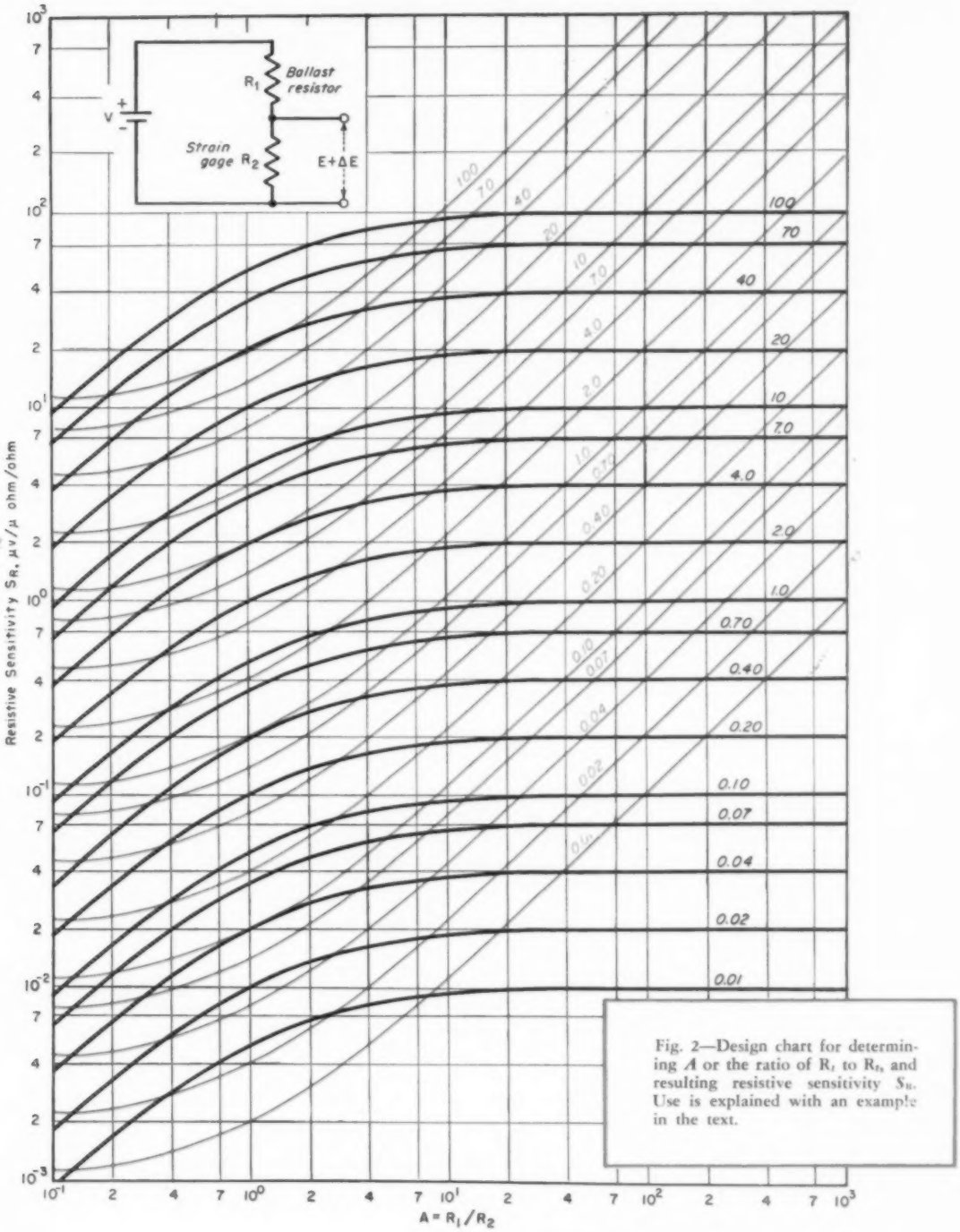


Fig. 2—Design chart for determining A or the ratio of R_1 to R_2, and resulting resistive sensitivity S_R. Use is explained with an example in the text.

Third, if:

$$\left(\frac{\Delta R_1}{R_1}\right)_T = \left(\frac{\Delta R_2}{R_2}\right)_T = \left(\frac{\Delta R_3}{R_3}\right)_T = \left(\frac{\Delta R_4}{R_4}\right)_T$$

So long as all four arms of the bridge have identical properties and are maintained at identically the same temperature, bridge output remains unaffected by temperature. *Voltage sensitivity can be increased* by increasing A. If two gages are placed in arms R_1 and R_2 of the bridge shown in Fig. 2 (B), A is unity and bridge sensitivity is 0.50 from Eq (23). If two gages are placed in arms R_1 and R_4 of the same bridge, A may be selected to give a higher sensitivity value, for example 0.91 for a value of A equal to 10. Hence, in designing strain gage bridges choice of gage location in the bridge is significant. For example, a properly designed two-gage bridge can be made to have practically the same sensitivity as a four-gage equal-arm bridge. Considerations such as temperature stability, noise level, and input impedance of the measuring instrument placed across the bridge terminals must also be considered.

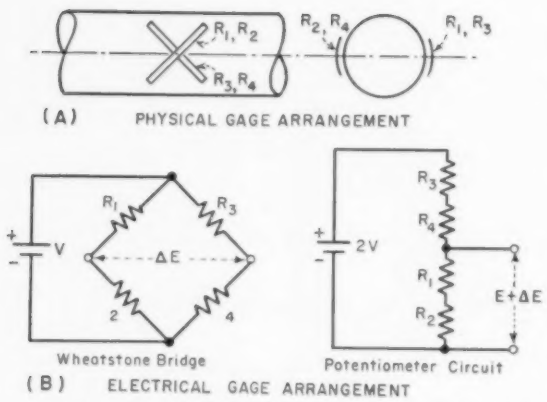


Fig. 3—Conventional physical gage arrangement (A) for torquemeter; (B) gages connected as a bridge circuit and as potentiometer circuit. Supply voltage V is now twice that used for bridge circuit. Both gage circuits have same sensitivity which is independent of uniform temperature changes in the shaft.

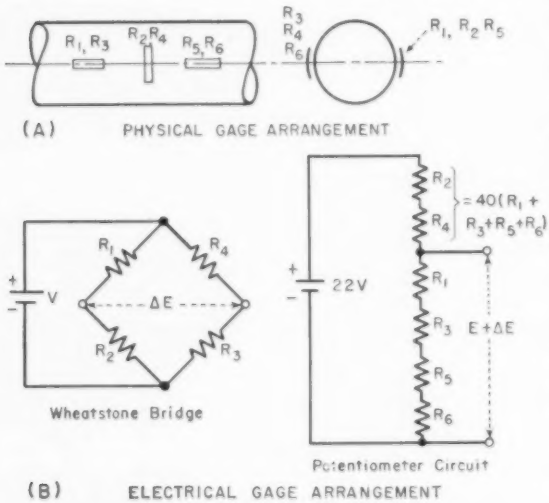


Fig. 4—(A) Physical arrangement of gages for measuring thrust in a shaft. When static as well as dynamic thrust must be measured, the bridge arrangement at left in (B) is used. Where only dynamic thrust components are to be measured, potentiometer circuit (B) has increased sensitivity.

Design for Dynamic Studies

For measurement of dynamic quantities such as strain, force or torque, where the static component is not of interest, the potentiometer circuit frequently is superior to a bridge. For example, the conventional physical gage arrangement for torquemeters, shown at (A) in Fig. 3, may be connected electrically as a bridge (B) or a potentiometer circuit (C). The same gage currents are used in both circuits. Both electrical arrangements respond to torque in the shaft with the same sensitivity, independently of thrust or bending on the shaft and also independently of uniform temperature changes in the shaft. The potentiometer circuit uses one less slip-ring than the bridge and requires only one continuous ground lead to connect the dc power supply, gage, amplifiers, and read-out instrument, thus minimizing stray pick-up effects. However, the potentiometer circuit does not respond to static torques—which is its main limitation.

TEMPERATURE EFFECTS

The potentiometer circuit is usually followed by a filter which eliminates the static voltage component and other low-frequency components as well. This may be used to advantage when slowly varying temperature changes exist in the structure under test. So long as the temperature fluctuations occur at a substantially slower rate than the dynamic strain changes, the temperature effects can be eliminated by an appropriate filter. Thus, the potentiometer circuit, not temperature-compensated, will not indicate temperature effects. However, if any strain fluctuations occur at these low frequencies, they will be also filtered out.

If four gages are to be used to measure thrust in a shaft and if static thrusts are of interest, the conventional thrust-meter bridge arrangement shown at (B) in Fig. 4 is used. This arrangement is self-temperature compensated for uniform temperature changes in the shaft. Both bridge and potentiometer circuits, shown in (B), are insensitive to bending or torsion in the shaft. The same gage current is used for both circuits. If only dynamic thrust components are to be investigated, and if only slowly varying temperature fluctuations are expected (temperature may vary slowly over a wide range), the potentiometer circuit at (B) in Fig. 4 has the following advantages:

1. The four gages can be mounted to give increased sensitivity as shown in the physical gage arrangement in (A). For the potentiometer circuit values shown, a gain in sensitivity of $(4 \times 0.91)/(1 + \mu)$ has been achieved, where μ is Poisson ratio for the shaft material. For steel this sensitivity increase is 2.8 times that of the conventional circuit.

2. The potentiometer circuit uses only one-half the number of slip-rings for one thrust-measuring channel and only one additional slip-ring for each additional channel.

3. Temperature effects can be eliminated by a filter, and it is permissible to use C-type gages rather than the A-type which are recommended where temperature compensation is to be achieved. This substitution results in an increased sensitivity factor of about 1.8 bringing the improvement factor of the potentiometer circuit to 4.

4. A common ground lead may be run through the entire system thus minimizing stray pickup effects.

Whenever the sensitivity or the circuit efficiency is a function of the resistance change in the gage, non-linearity is present. Fortunately, nonlinearities are negligible for most applications since maximum range of strain gage resistance variation is normally less than 5 per cent of nominal gage resistance, and for most elastic strains this variation is less than 1 per cent. In general, N need be considered only in such studies as post-yield investigations. The amount of non-linearity may be defined as follows:

$$S_N = S_L (1 - N) \tag{33}$$

where S_L is sensitivity in linear region of the system and S_N is the sensitivity at the operating point.

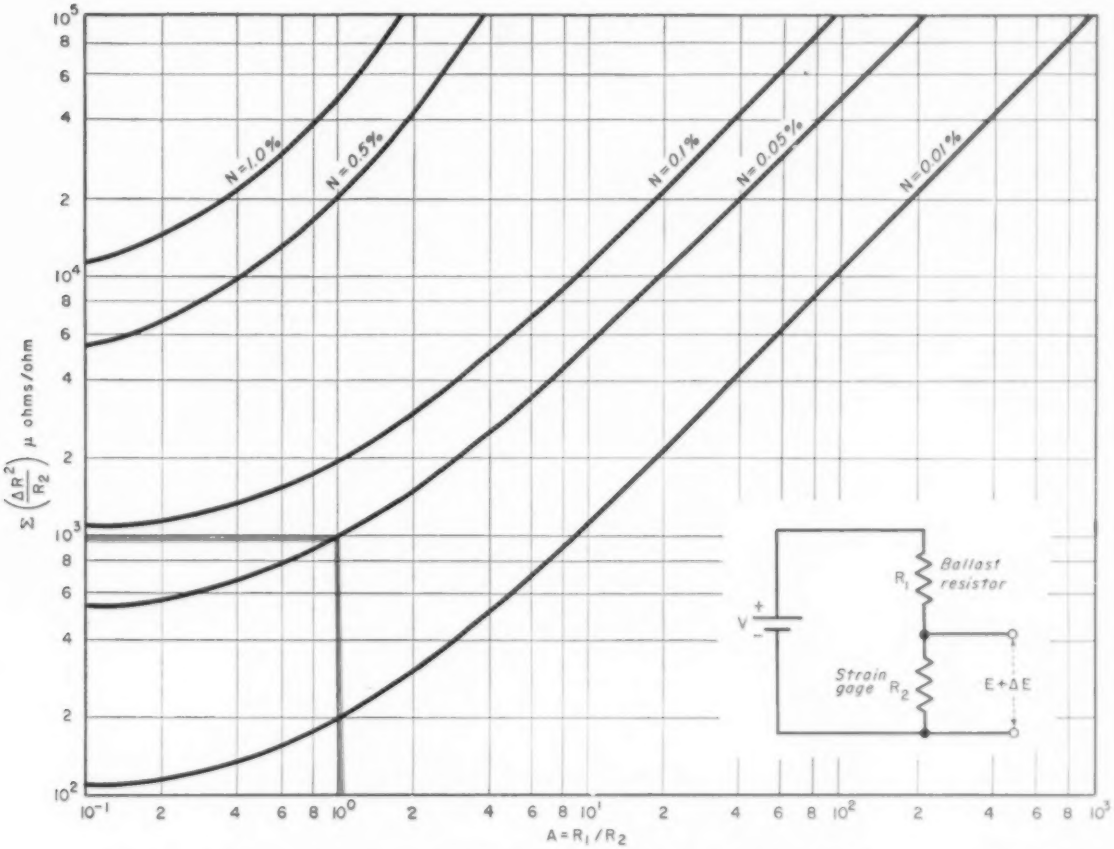


Fig. 5—Chart for determining, for any given value of A, maximum total unit resistance change $\Sigma(\Delta R_2/R_2)$ which can exist in either potentiometer or bridge circuit before maximum degree of nonlinearity N is reached. A is read along bottom scale and from desired value a vertical line is drawn intersecting curve of maximum degree of nonlinearity which can be tolerated. From this point line is drawn to left hand scale to give $\Delta R_2/R_2$ in micro-ohms per ohm. This figure divided by gage factor gives value of micro-inch per inch strain indication.

LINEARITY DETERMINATION

Fig 5 shows a plot of

$$N = \frac{1}{1 + \dfrac{A+1}{\Sigma\,(\Delta R/R)}} \tag{34}$$

where $\Sigma(\Delta R/R)$ denotes whatever linear combination of strain-induced resistance changes are necessary to identify Eq (33) with Eq (5) for a potentiometer circuit or Eq (11) for a Wheatstone bridge.

For any given value of A, Fig. 5 shows the maximum equivalent total-unit resistance of $\Sigma(\Delta R/R)$ which can exist in either type circuit before a given non-linearity N is reached. For example, in a Wheatstone bridge with arm R_1 active and arms R_2, R_3, and R_4 dummies of the same resistance as the active gage, $A = 1$. To operate at non-linearity factors of less than 0.05 per cent, R_1/R_2 must be less than 1,000 microohms per ohm which is a 500 microinch per inch strain in a 2.00 gage-factor gage.

First order non-linearity effects are zero when:

$$\sum\left(\frac{\Delta R}{R}\right) = 0 \tag{35}$$

When A is equal to 1, this occurs for a potentiometer circuit when:

$$\frac{\Delta R_2}{R_2} = -A\left(\frac{\Delta R_1}{R_1}\right) \tag{36}$$

and for a Wheatstone bridge when:

$$\frac{\Delta R_2}{R_2} + \frac{\Delta R_3}{R_3} = -A\left(\frac{\Delta R_1}{R_1} + \frac{\Delta R_4}{R_4}\right) \tag{37}$$

For a potentiometer circuit Eq (22) is satisfied by using two gages R_1 and R_2 on opposite sides of a cantilever beam in bending. In this manner a completely linear circuit may be designed. However, linearity is obtained at 50 per cent decrease in maximum sensitivity.

CITED REFERENCES

(1) Murray, W. M., and P. K. Stein, *Strain Gage Techniques*, Massachusetts Institute of Technology 1955, page 236.

(2) *Measurement of Stress and Strain in Solids*, London Institute of Physics, 1948.

(3) Manual on *Experimental Stress Analysis Techniques*, SESA, 1954.

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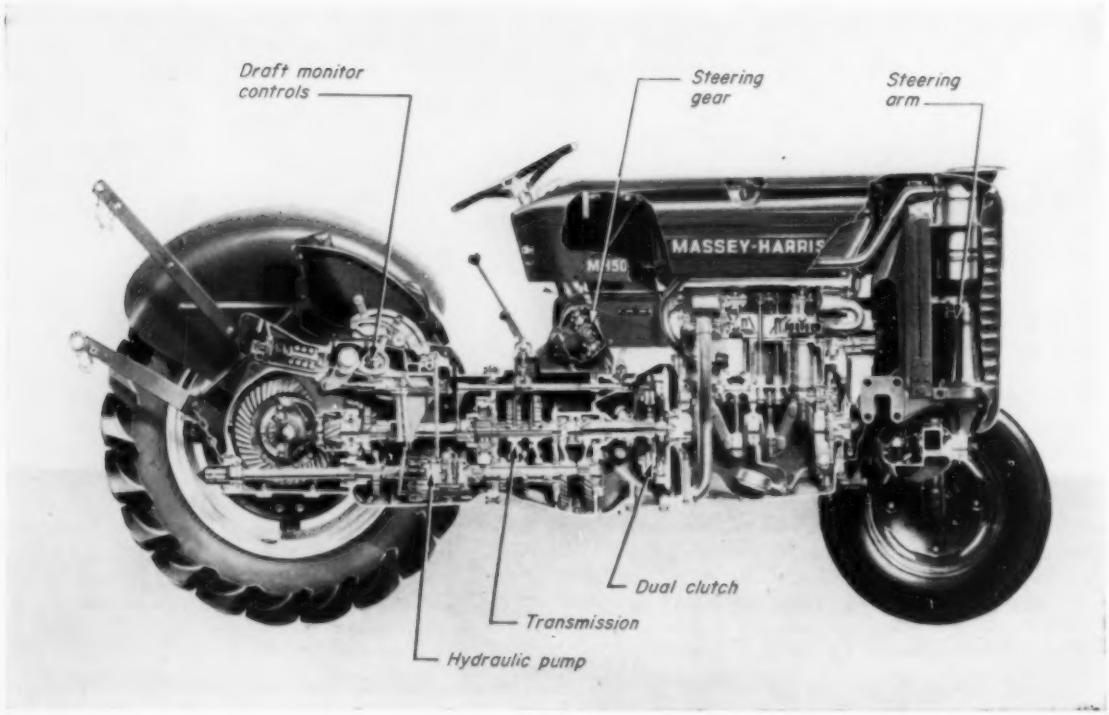
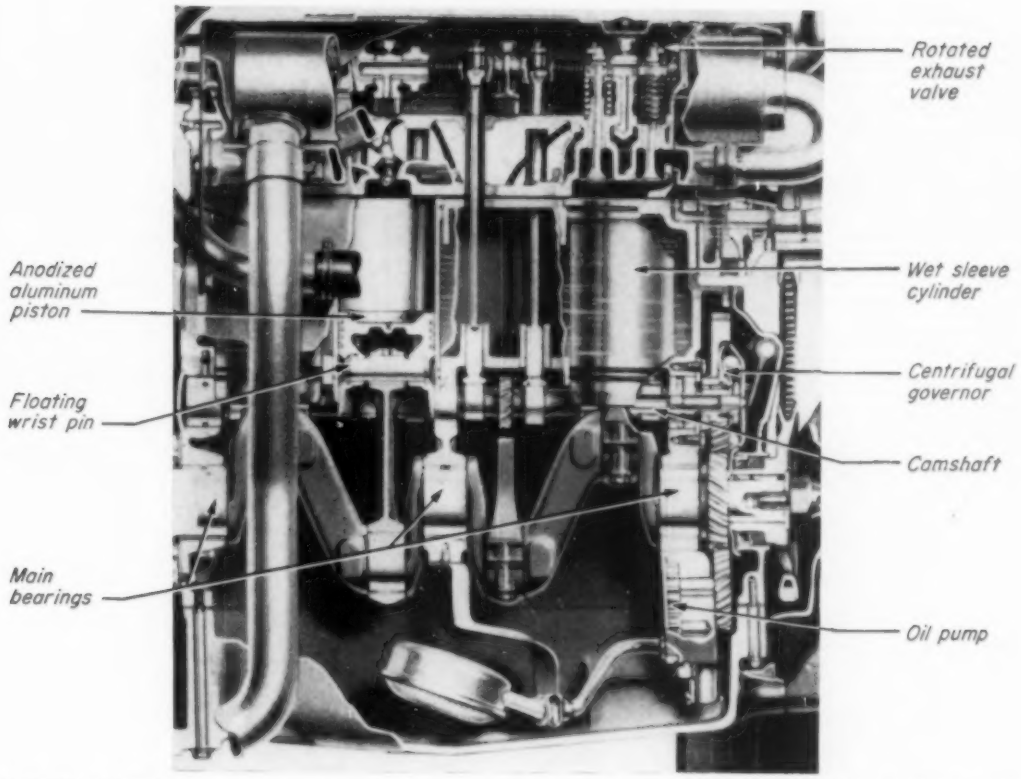
DESIGN FEATURES

High Torque Engine, Dual Clutch and Hydraulic Controls Give Tractor More Utility

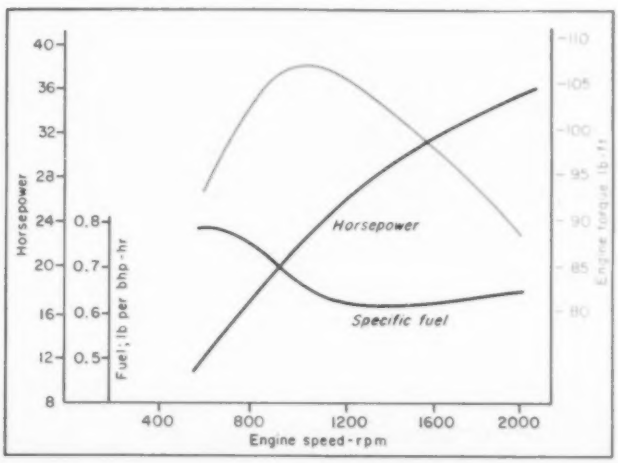
When Massey-Harris-Ferguson engineers designed the MH50 tractor, they used a high compression engine with replaceable cylinders, aluminum pistons, rotated exhaust valves and a wide-range centrifugal governor. A dual clutch with one pedal, a compact compound transmission and an automatic hydraulic implement control system transmit its power. Simple steering linkage for 3 front-end variations and power-adjusted rear wheel tread complete the list of design improvements.



IN NEW PRODUCTS



ENGINE CYLINDERS are replaceable wet sleeve type, machined inside and out for more uniform cooling and less distortion. They are made of cast alloy iron for high wear resistance. To avoid preignition, pistons are aluminum alloy castings; steel belt inserts control expansion and allow fitting tolerances similar to those of cast iron pistons. Surfaces are anodized to retain lubricant and resist wear. Connecting rods are "H" section steel forgings fitted with interchangeable steel-backed bearing liners at the crank end. Piston ends have diamond-bored bronze bushings. Wrist pins float in pistons to avoid localized wear; they are retained by hardened snap rings. Intake valves are S.A.E. 3140 chrome nickel steel while exhaust valves are austenitic steel. Rotation of exhaust valves increases valve and seat life.



TO RESIST STALLING under unexpected overloads, engine develops maximum torque below normal operating speeds. Maximum horsepower is developed above normal speed range to give reserve when needed. This high compression engine has a $3\frac{1}{8}$ in. bore, a $3\frac{7}{8}$ in. stroke, and 133.8 cu in. displacement. It develops 40 hp at 2000 rpm and a torque of 112 lb-ft at 1400 rpm. A variable-speed centrifugal governor is attached to the camshaft gear; governor mechanism includes 10 ball weights and is inside timing gear housing. Engine speeds from 450 to 2200 rpm can be selected.

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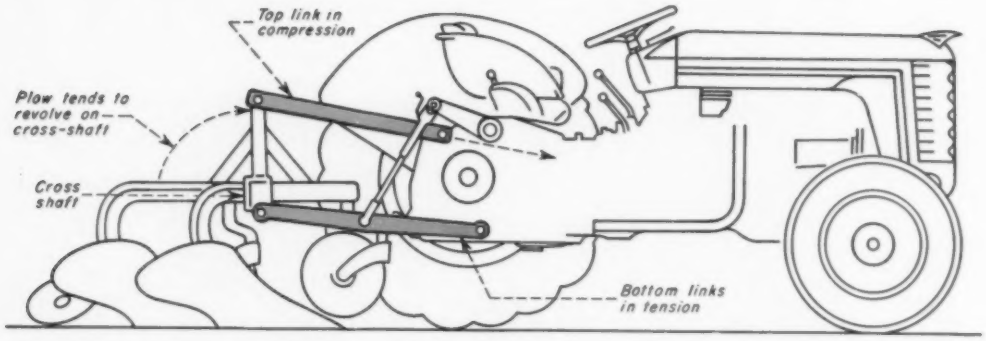
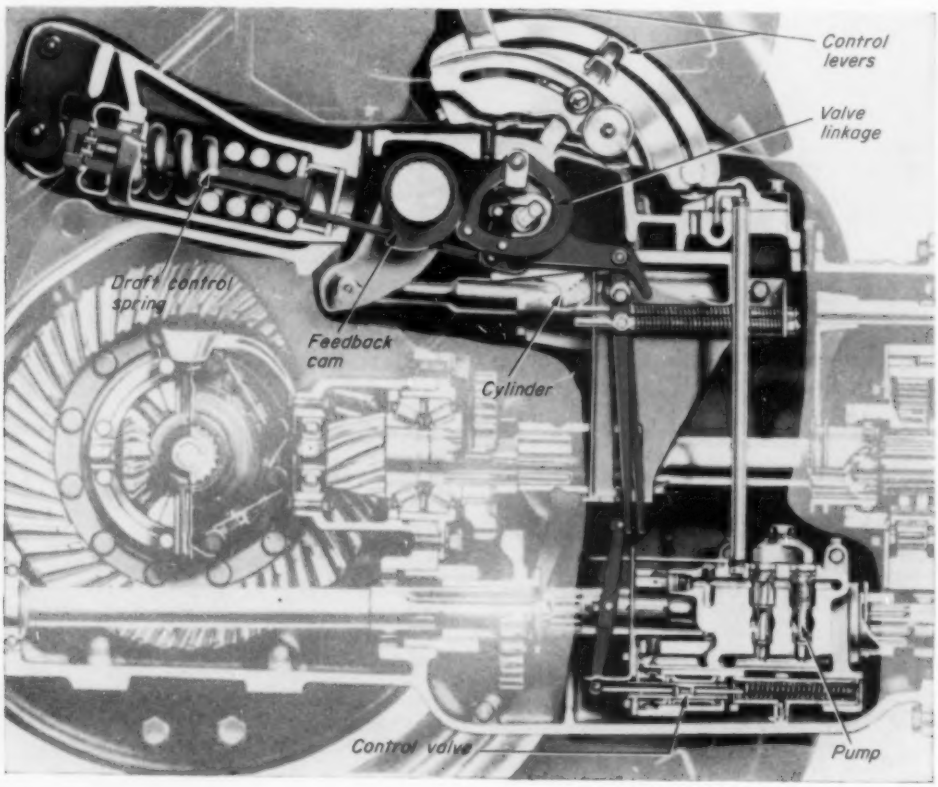
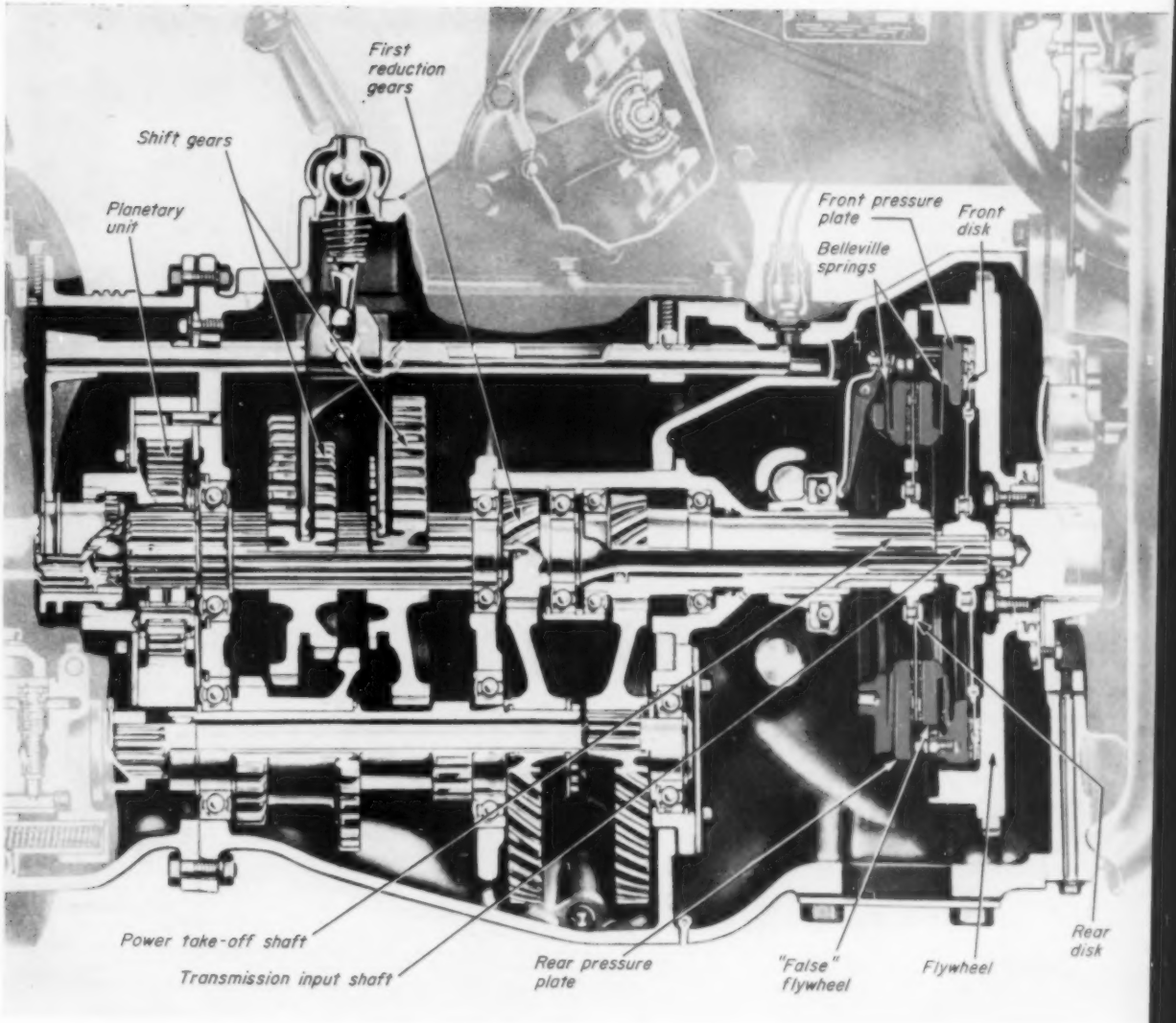


THREE LINKS ATTACH IMPLEMENTS to tractor, dividing resistance into 3 components. Lower links are in tension and upper link is in compression. This gives traction without excessive built-in weight as part of implement's weight is carried by tractor. A hydraulic control system raises, lowers or maintains soil depth of implement. Upper link serves as sensing element for the hydraulic control; lower links are positioned hydraulically by the rocking shaft lever to correct depth errors. A response control adjusts oil flow rate for stable action.



HYDRAULIC SYSTEM is an integral part of tractor. The 4-piston pump is mounted on and driven by an extension of the transmission counter shaft. Pump can deliver 3 gpm at 1900 psi. Flow is controlled by a valve at pump inlet port; this valve controls all action including fast overload release. Cam on pump shaft produces dither by rocking the valve. Implements are raised when oil is pumped to the single acting cylinder; they are lowered when their weight forces oil from cylinder through control valve. Response rate is set by throttling valve ports. A double-acting draft monitor spring element in linkage to the control valve meters corrective action required. Normal operation loads spring to 3000 lbs; a 2000 lb load increase actuates a release mechanism to dump oil from the cylinder. This reduces rear wheel traction and stops forward motion. Cam on rocking shaft feeds cylinder motion back into control valve linkage to stabilize the action. Overriding motions of position and depth controls modify linkage position at this point to set implement working level.



FRONT DISK OF DUAL CLUTCH is splined to transmission input shaft; rear disk is splined to hollow hydraulic pump and power take-off shaft. A false flywheel ring between sets of disks and pressure plates is the contact surface for rear disk. This ring and the cover are bolted to flywheel. Belleville springs hold pressure plates in engaged position; a single clutch pedal actuates both disks. Initial motion moves front pressure plate against first spring releasing disk from flywheel. Continued motion moves rear pressure plate against second spring to release rear disk from false flywheel ring.

Spur gear transmission is compounded by planetary reduction unit. Main transmission has 3 forward and 1 reverse speeds. All gears are case hardened alloy steel forgings; first reduction has helical gears while straight spur gears are used to change speeds. All shafts are supported on ball bearings. Planetary unit is coupled to rear of main transmission shaft; it gives a 4 to 1 speed reduction. Ring gear is fixed to transmission wall and planet pinion carrier is the rotating member. Helical gears are used in first reduction; spur gears in speed changing section simplify construction and shifting action.

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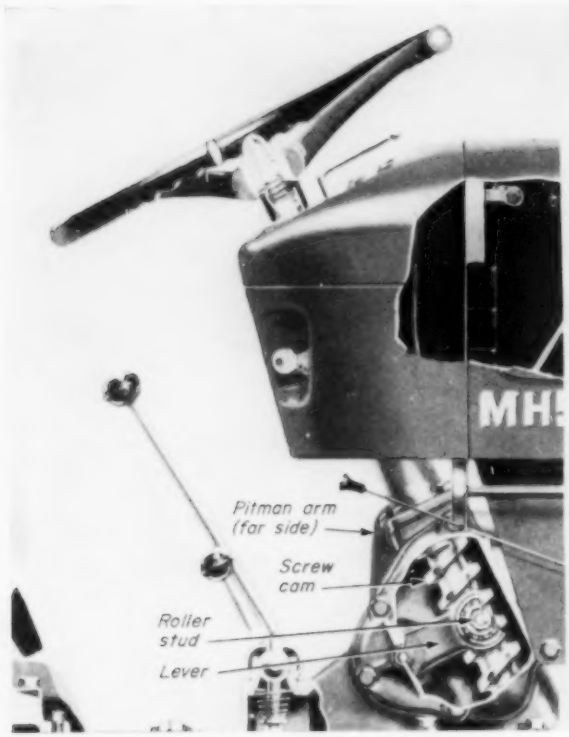
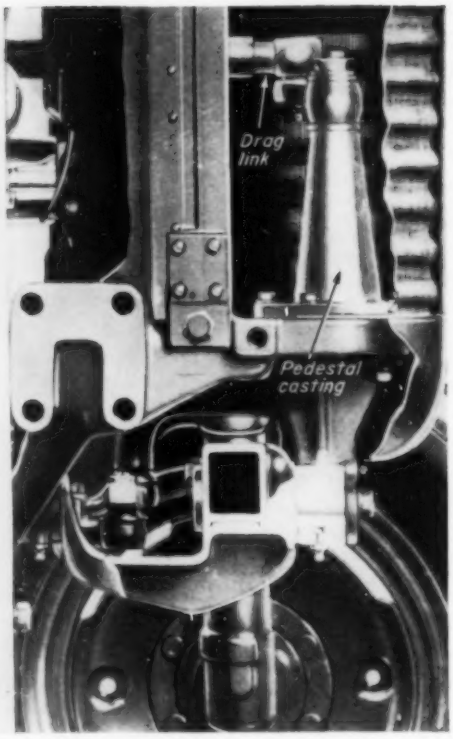
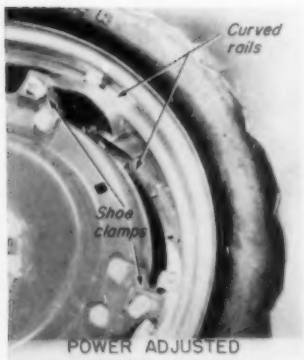
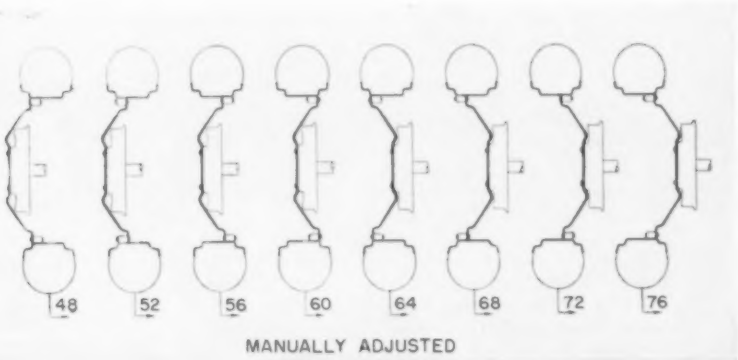




STEERING GEAR is cam and lever type with a single pitman arm. Roller type stud follower shown is used on 4-wheel tractors for low hand wheel effort and fast steering. Approximately 3 turns are required from lock to lock. A plain fixed stud and 4¼ turns are used on tricycle units to reduce front wheel shock common to this type tractor. A single drag link connects the pitman arm to lever on pedestal casting at front of tractor. Pedestal casting supports vertical shaft in bronze bushings. Lower end of shaft has indexed splined connection to steering arm for type of front axle used. Linkage is designed so power steering can be added with minor changes. Pedestal casting, vertical shaft and upper arm are replaced with new parts; power cylinder mounts on front axle support and pump is attached to machined flange on engine. Hose lines from pump to cylinder complete the conversion.

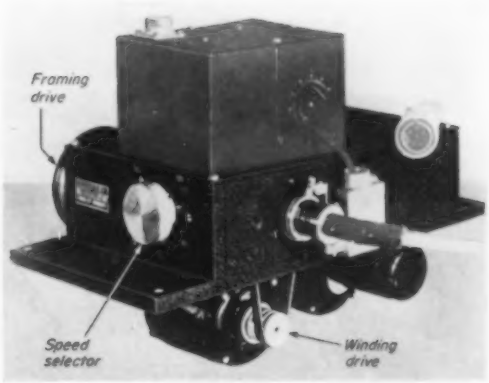




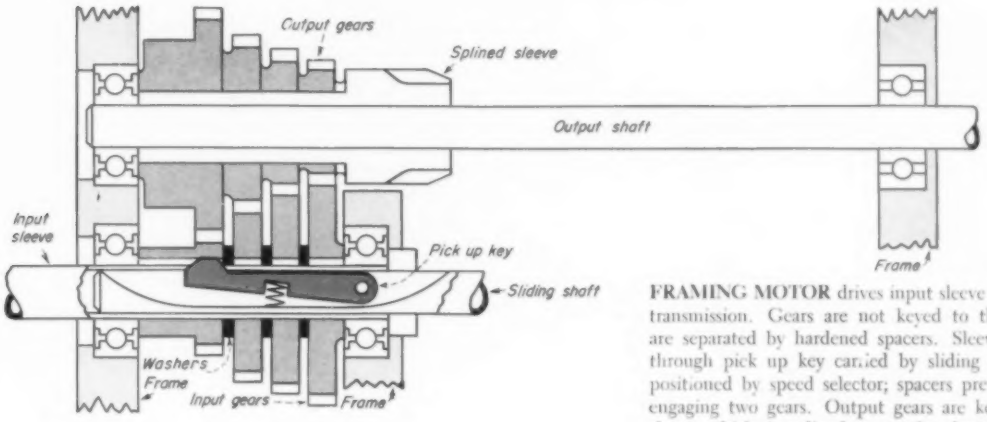
REAR WHEEL DISKS are positioned on hubs and rims in 8 ways to change tread of standard tractor. Special units have power adjusted rear wheels for treads of 52 to 72 in. Intermediate positions are set with shoe-clamps which slide on curved rails in rim. Tractor motion rotates disk relative to rim, moving shoes along rails. Clamps are tightened at proper setting. Dual rear wheels may be added to give more traction in loose textured soil.

Stop-Motion Motor Indexes to 1 Revolution

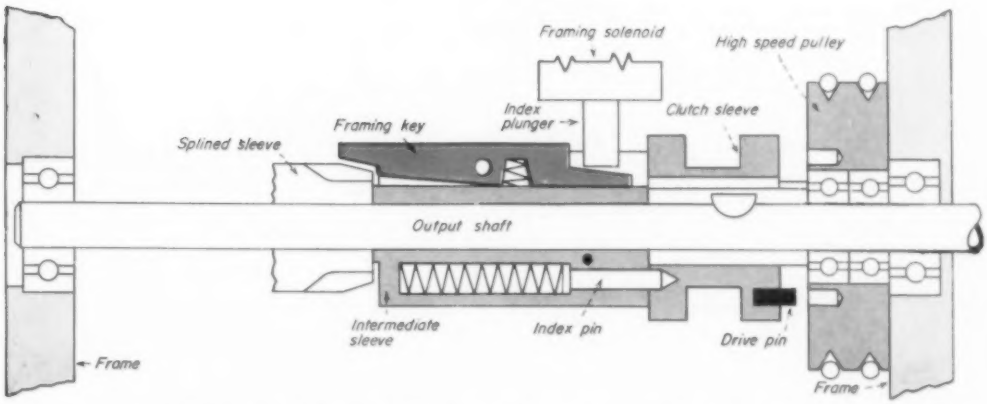
To make animated films, one frame is exposed at a time. Also, when refilming silent movies, 4 frames must be made for each 3 in the original as projector speeds have increased from 16 to 24 frames per sec. This is done by driving processing equipment with a stop-motion motor. Designed by John Oxberry of Animation Equipment Corp., New Rochelle, N. Y., it has 4 indexed framing speeds and a 5th speed for fast winding.



UNIT IS SHOWN as mounted on animation stand. See "Low-Friction, No-Play Mechanisms Maintain Precision in Camera Stand", January 1956. Compactness results from mounting motors below base plate; they power separate single-framing and continuous-winding drives. A push button or foot switch controls motion by energizing the solenoid operated clutches.



FRAMING MOTOR drives input sleeve of the 4 speed transmission. Gears are not keyed to this sleeve and are separated by hardened spacers. Sleeve drives gears through pick up key carried by sliding shaft; shaft is positioned by speed selector; spacers prevent key from engaging two gears. Output gears are keyed to driven sleeve which is splined to receive framing key. This sleeve rotates on output shaft but does not drive it.



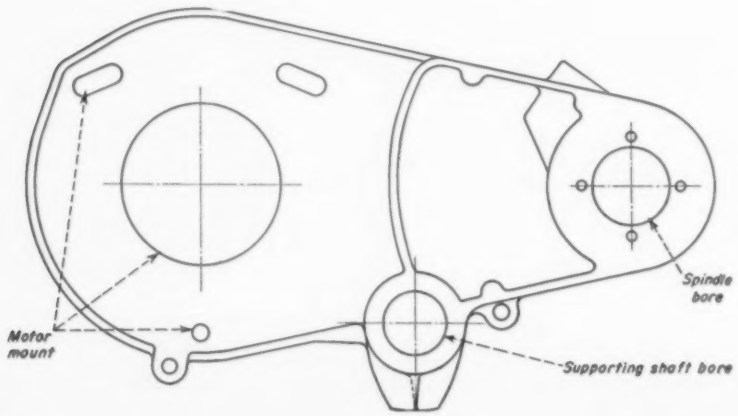
FRAMING ACTION STARTS when solenoid pulls index plunger from slot in intermediate sleeve. Framing key then engages splines in transmission output sleeve. When released, plunger re-enters slot, depresses key, and stops motion. Output shaft is driven by the sliding clutch sleeve which is positioned by a second solenoid. Clutch is shown engaged with framing drive. Single pin connection couples shaft only in indexed position. When moved to right, pin on clutch engages pulley of high speed winding drive.

Bearings Set in Rocking Saw Frame

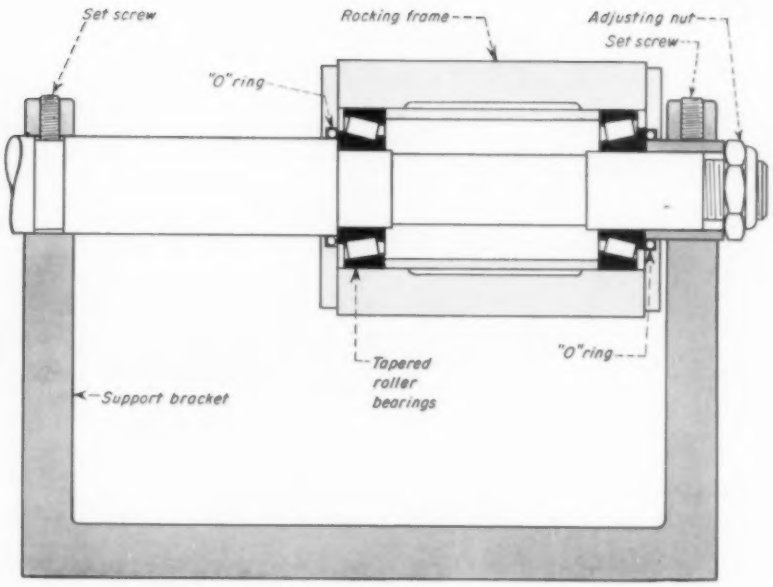
All critically aligned bearings are in one casting in the head assembly of an abrasive cut-off machine developed by the Walker-Turner Division of Kearney & Trecker Corporation, Plainfield, N. J. Stanley Burwell was the product development engineer.

A companion tool, a metal saw (above), incorporates the same bearing design, motor drive-guard, machined table and base.

MOVABLE GUARD is cast iron with straight-through chip travel; cover has quick-acting link-and-screw latches. High speed saw has a single jet mounted under the blade which can be used for liquid or mist coolant. Abrasive cut-off unit has a dust collector throat. Swivel-head model (not shown) uses same rocking frame but has swinging arm pivoted under table to avoid dirt and chips. Bases are wrap-around welded sheet steel. Straight handle is length of steel tube with grip at one end.

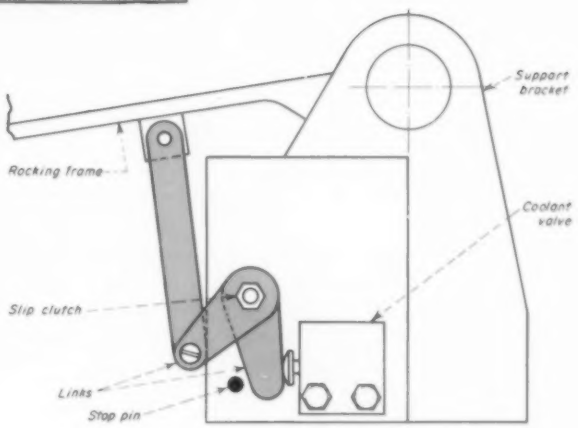


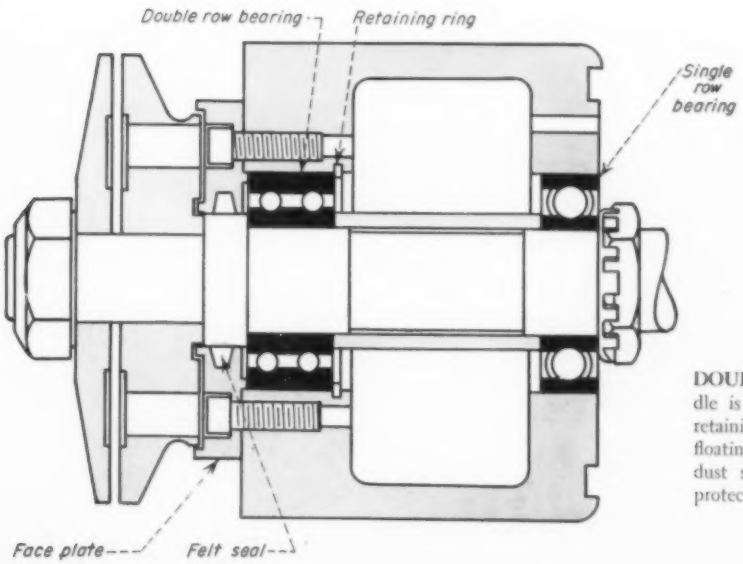
CASTING used for rocking frame maintains alignment of motor, spindle and supporting shaft. Spindle and shaft bores are machined in one set up.



PIVOT SHAFT BEARINGS mount in rocking frame with outer races spaced by a bushing. Inner race of left bearing fits against shaft shoulder; inner race of right bearing is held by bushing on the shaft. A single adjusting nut sets clearances in both tapered roller bearings; shaft ends are then clamped to support bracket by set screws. "O" rings in cover plates are dust seals.

SIMPLE SLIP CLUTCH actuates control valve for cooling jet on saw models; liquid or mist coolant flows only during cutting stroke. Clutch is made of fiber washers mounted between steel levers; a belleville spring, stressed by a stop-nut, holds clutch engaged. Levers move as a unit to operate valve, then slip for balance of stroke. A pump and strainer for liquid cooling or a mixing valve and pressurized container for mist are mounted within base.

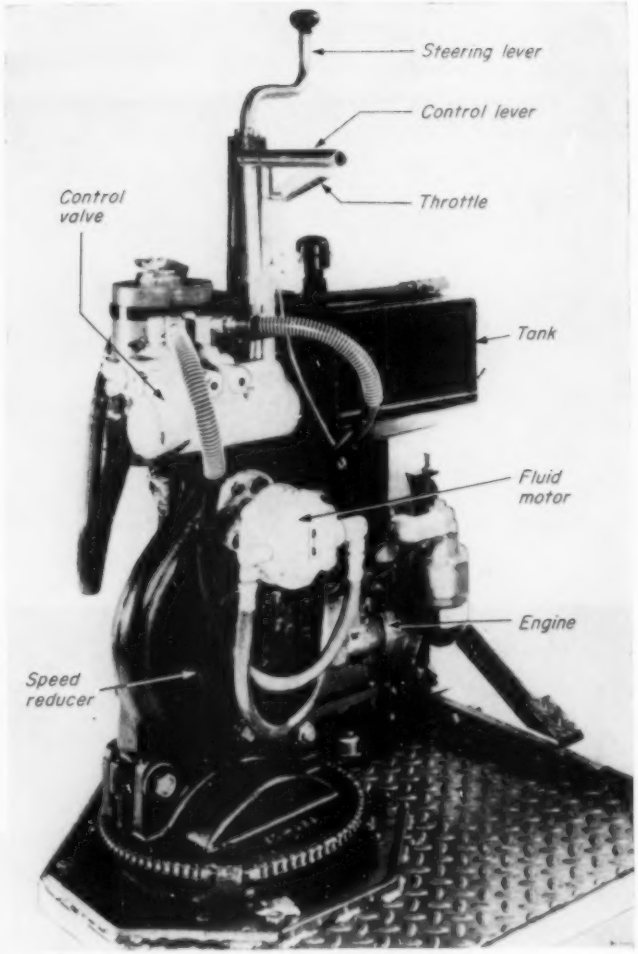




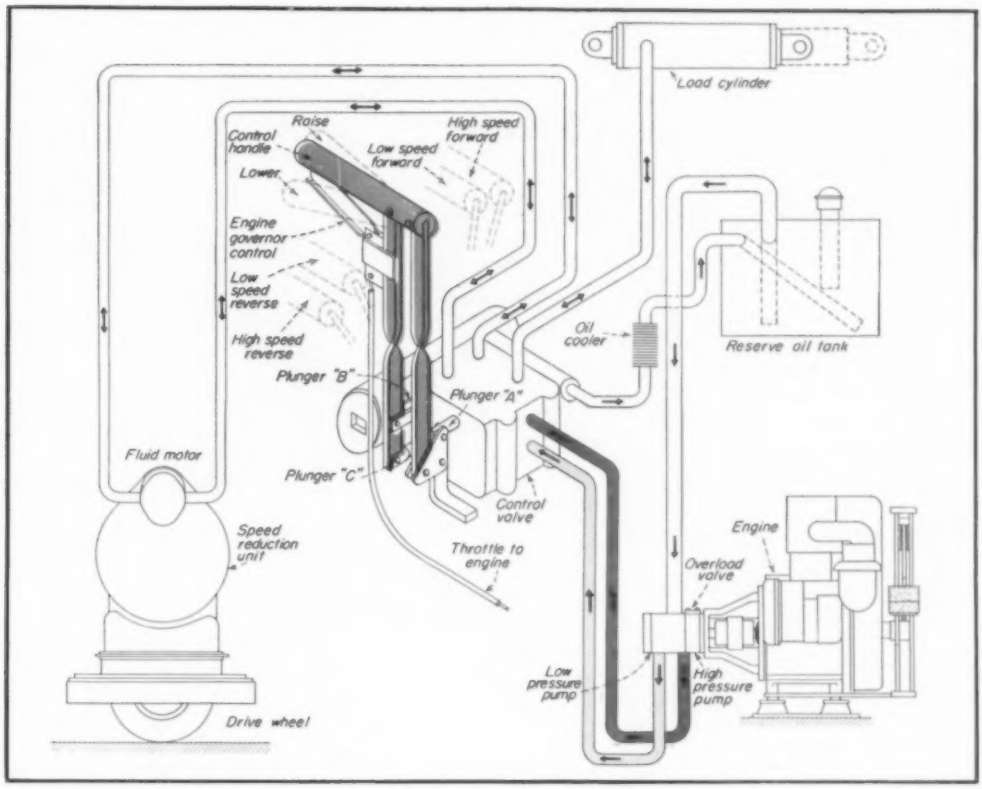
DOUBLE ROW BEARING on spindle is locked between face plate and retaining ring. Single row bearing has floating outer race. Face-plate has felt dust seal and machined labyrinth to protect bearing from abrasive dust.

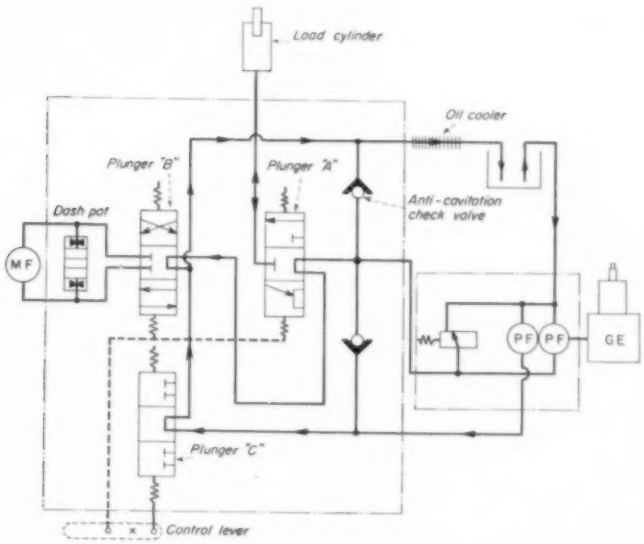
Lever Controls Hydraulic Truck

A dual pump and a single fluid motor give this pallet truck two speeds forward and reverse. By operating 3 valves, a single lever controls forward and reverse motion and lifts the pallet. Manufactured by the Colson Corp., Elyria, Ohio the unit has no clutch, transmission or friction brakes.



A 6 HP GASOLINE ENGINE drives the Hydreco dual pump at speeds up to 3000 rpm. The fluid motor runs at a top speed of 1550 rpm on 8.5 gpm at 400 psi; motor drives wheels through an 18-to-1 gear and chain reduction. The high-pressure pump section starts the unit and drives when climbing ramps or lifting. Both high and low pressure pump sections drive at high speeds. The truck is "inched" or driven at speeds up to 4 mph by varying the engine speed. Load capacity is 4000 lb. Unit is reversed without clutch or transmission by reversing the fluid motor. A dashpot in the valve housing cushions starts and stops. The fluid motor gives braking action when valve handle is moved toward neutral position. Valve is spring-loaded in neutral to act as a "deadman" brake. A safety valve in the high pressure pump prevents damage to truck or stalling of engine under overload conditions.



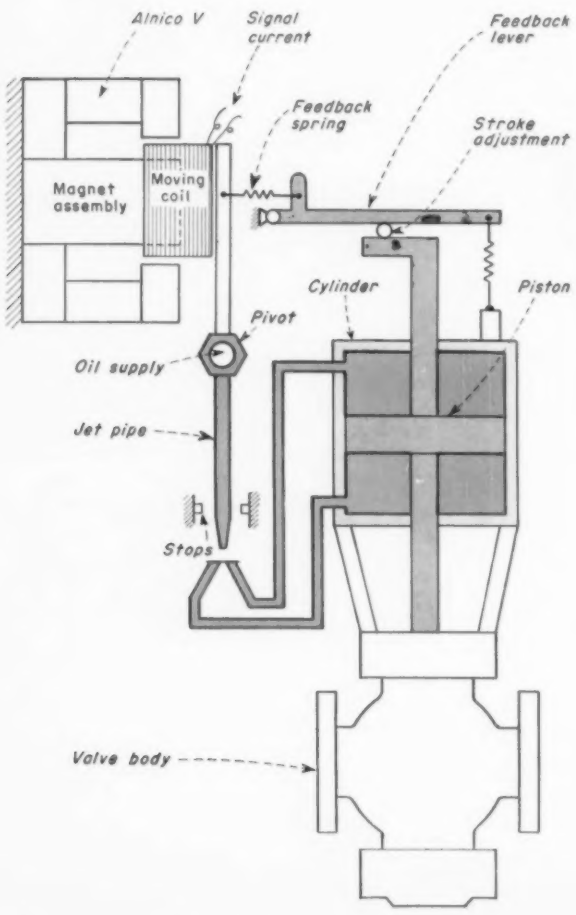


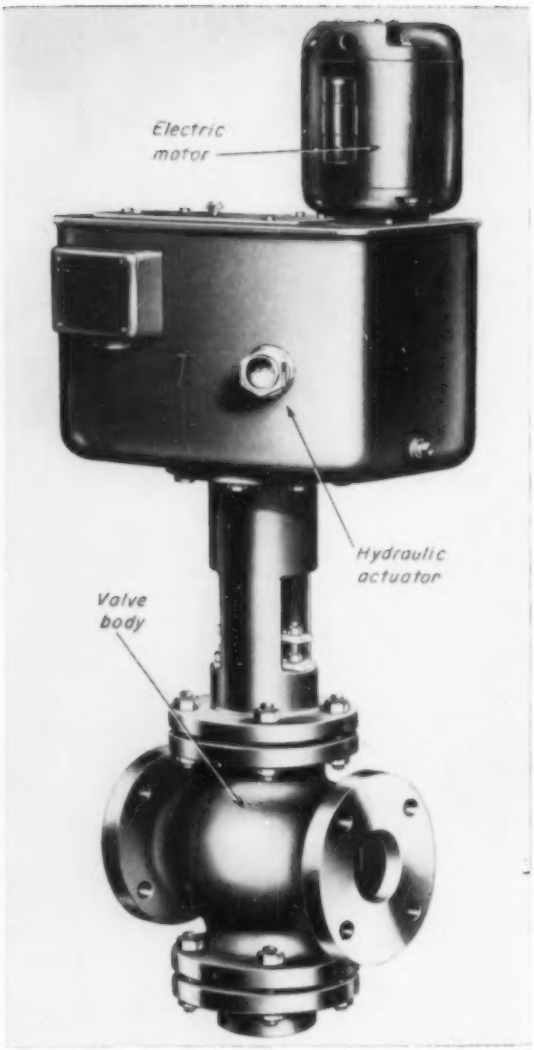
THE HYDRECO CONTROL VALVE has 3 spring loaded plungers, 2 check valves and a dashpot. The outputs of both pump sections are controlled at this point. In the neutral position, oil flows from both pump sections through the valve and back to the tank. The high pressure pump is connected to plungers A and B. Plunger A controls the lift cylinder. In "raise" position, oil flows from pump to cylinder; in "lower" position, oil flows from cylinder to tank. Plunger B controls direction of rotation of fluid motor. Motion halfway forward or reverse connects fluid motor to high pressure pump for high-torque low-speed motion. The low pressure section of the pump is connected to plunger C and, through a check valve, to plungers A and B. Pushing the handle all the way forward or reverse causes plunger C to direct oil from low pressure pump through checkvalve. This combines pump outputs to drive motor at high speed.

THE SECOND CHECK VALVE (designated "anti-cavitation") connects valve input to reserve tank to prevent cavitation in the fluid motor when braking. This happens when the truck goes down a steep ramp or is slowed from high speed with the engine running at low speed. The cushioning action of the dashpot is varied by flow rate adjustments in the valve body. A length of finned copper tubing cools the oil flowing between the valve and the tank.

Hydraulic Drive Replaces Air Motor

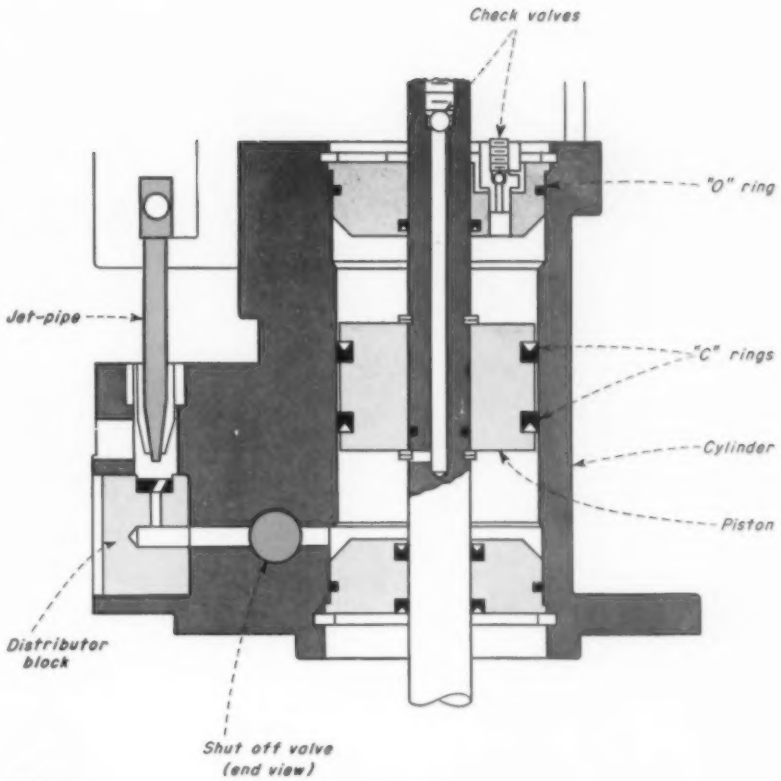
Askania Regulator Co., Chicago, Ill. has designed an electro-hydraulic valve actuator that works directly with electronic control instruments. It had to be simple and rugged like a diaphragm motor but respond to signals of low power level. A moving coil transducer and a hydraulic relay convert these electric signals into hydraulic power. This gives greater speed and higher forces than the pneumatic drives it will replace.

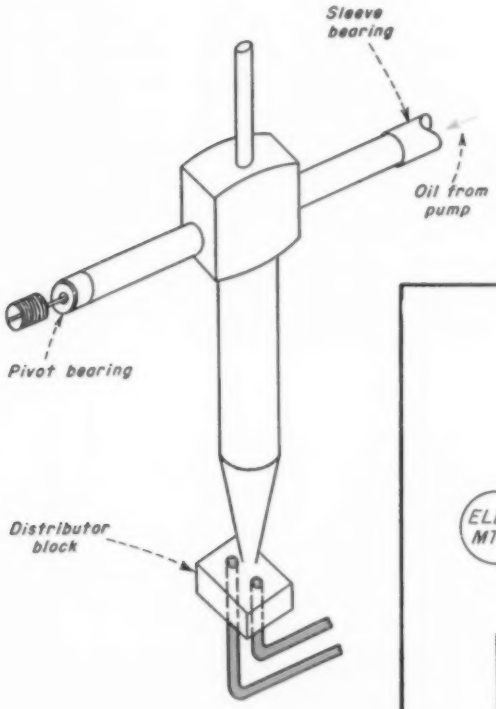




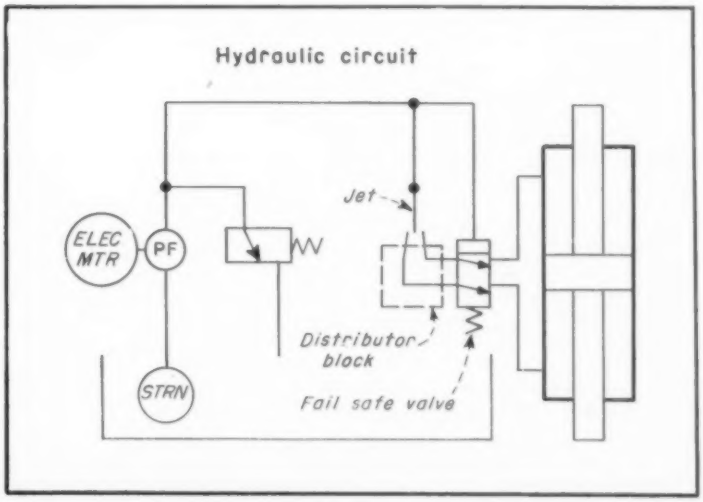
THE ACTUATOR replaces diaphragm and spring of a pneumatic motor and mounts on the control valve. Only connections are controller signal wires and power leads for ¼ hp pump motor. Moving coil in a permanent magnet field converts the signal into a force which operates a jet pipe hydraulic relay. The jet pipe regulates the oil flow to the power cylinder. Moving the jet pipe from neutral position directs high pressure oil into either end of cylinder. Pressure rise causes piston to move against load; feedback lever follows motion and balances force of moving coil by changing length of feedback spring. This returns jet pipe to neutral position and stops piston motion. Shifting roller between feedback lever and piston rod adjusts ratio of piston travel to magnitude of signal change. Resolution sensitivity of this positioning mechanism is within 0.1 per cent. Power level required is 4 to 4.5 ma with load resistance less than 18,000 ohm. Alnico V is used for the magnets; soft iron for the rest of the magnetic path.

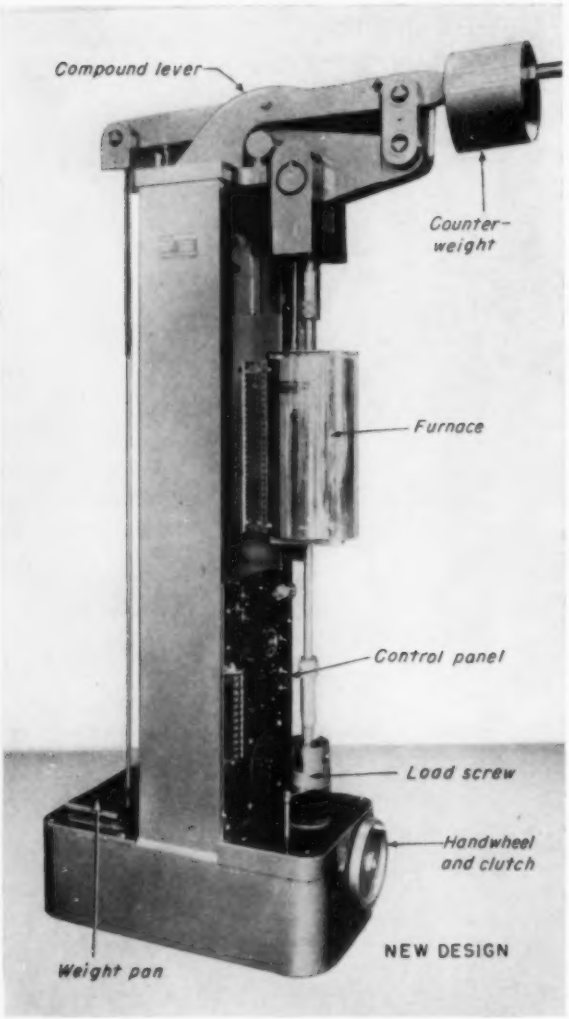
POWER CYLINDER has 2.5 in. bore and 2 in. stroke; stroke is varied between 0.5 and 2 in. for normal signal changes. Maximum force developed is about 1000 lb.; this is over twice the force of a diaphragm and spring motor. Pump delivers 1 gpm at 230 psi which will drive piston 1 in. in 1.2 sec at no load, about 4 times the speed of a diaphragm motor. Mounting the pump inside housing reduces possibility of oil leakage. Ball check valves in cylinder and piston rod vent trapped air when unit is put in operation. Balls are seated by screws with axial bore; loosening screw allows air to escape. A spring loaded spool-type shut-off valve blocks cylinder ports to hold position if hydraulic power fails. "O" rings seal static joints while "C" type packing rings seal sliding joints.





OIL PRESSURE IN THE JET PIPE is 200 to 300 psi. Oil leaks through a sleeve bearing to support the jet pipe on the oil inlet side; opposite end rests in ball-bearing pivot, also bathed with oil. A torque of about 0.03 in. oz will move jet. About 96 per cent of the jet's kinetic energy is recovered as static pressure in the cylinder.



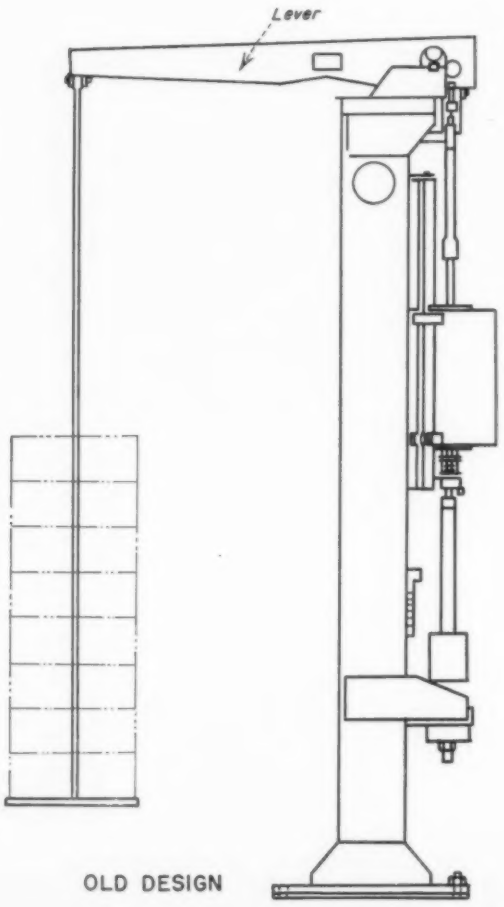


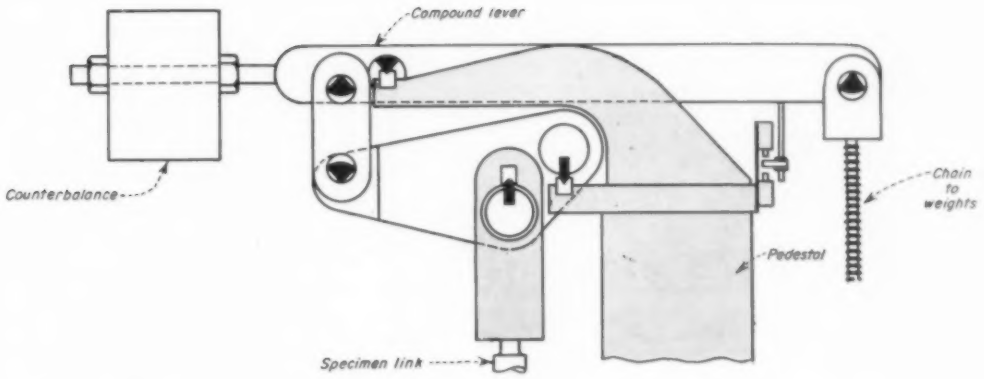
Creep Tester Makes Three Basic Tests

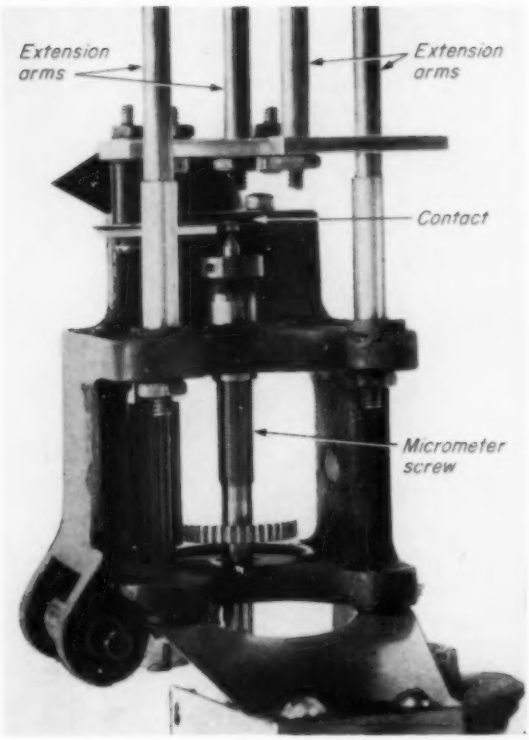
A creep testing machine developed by Baldwin-Lima-Hamilton Corp., Cambridge, Mass. uses 2 head assemblies and a motor driven loading screw to make possible 3 types of tests. A compound loading lever which is counterbalanced and kept level makes the unit compact and accurate.

THE BASIC MACHINE performs long time creep tests. Deformation measurements are taken with respect to time with stress and temperature held constant. Old design had a simple loading lever and no loading screw. The lever changed position and altered arm ratio as specimen stretched, introducing a change in load. Weights dropped as much as 10 in. when the specimen broke and impact affected tests on other machines. The heavy lever fixed a relatively high lower load limit; a 600 lb weight was needed to obtain the 12,000 lb load capacity. Machine had to be bolted to floor.

The new design takes about the same floor space but a compound lever gives 20,000 lb capacity with a 500 lb weight. All controls are grouped at the front of the machine; upper controls are for extensometer when used while lower controls are for furnace and motorized loading screw. The furnace is counterbalanced by a weight inside pedestal.







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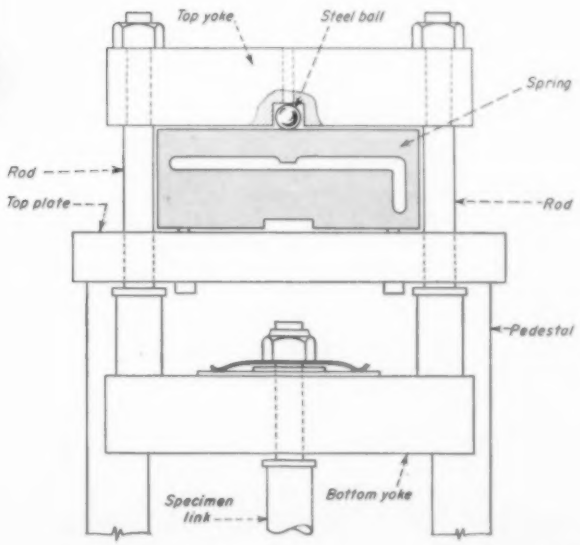
THE LEVER is counterbalanced to give zero tare. A mercury level switch energizes the motor driven loading screw which moves down to keep the lever horizontal as the specimen stretches. This holds the load constant and keeps weights close to base; specimen rupture causes little impact. Weights hang over base so unit is not bolted to floor. The knife edges are purchased from a scale manufacturer.

◀

THIS EXTENSOMETER measures strain only over a 2 in. gage length inside the furnace. Two arms extend from each end of the specimen to an electric contact assembly below the furnace. Strain is amplified by a lever system to move contact relative to the micrometer screw. Extension of specimen brings contact against micrometer screw which energizes a follow-up drive, rotating screw until contact is broken. The screw motion is transmitted mechanically to the extensometer control panel on the machine. It is used when more precise strain measurements are required or strain is held constant.



THE MACHINE IS ALTERED for creep-rupture tests by replacing the lever mechanism with a spring-block assembly. Block is about ½ in. thick with a milled slot to make top portion a stiff spring. The higher loads required for this test are applied by the loading screw. Load is transmitted from specimen to spring by yokes and rods guided by holes in pedestal top slate. A steel ball concentrates the load at the spring center. A differential transformer (not shown) gages spring deflection and energizes the screw drive to hold load constant. Screw motion is a measure of strain and is used to drive recorder. For relaxation tests, an extensometer controls screw motion for constant strain; the differential transformer then measures load and drives recorder.

Centrifugal Pendulum

Application and Design

Derivation of formulas for torque, energy and time to swing. A sample calculation illustrates their application.

S. S. LINN, Senior Project Engineer
H. G. WENIG, Staff Engineer
Bulova Research and Development Laboratories, Inc.

THE PROBLEM of mechanically obtaining a time delay of short duration in a rotating body may be solved by a special application of the centrifugal pendulum. In addition to furnishing a time delay, the device also serves as a means of transforming energy or applying torque in a rotating device without any external connections. This may be accomplished by using the centrifugal field of a rotating body in conjunction with the centrifugal pendulum.

There are several variations of the centrifugal pendulum, the most common consists of an elongated mass which is pivoted and attached by the pivot pin to a rotating body as shown in Fig. 1. The location of the pivot is eccentric to the spin axis of the rotating body and if the pendulum is displaced from its equilibrium position while the carrier body is rotating, it will oscillate with a definte frequency. This pendulum is used in various forms for engine vibration dampers and is described fully in the technical literature.

The type of centrifugal pendulum which will be discussed in this article is shown in Fig. 2. This centrifugal pendulum consists of a pivoted, elongated mass or bar which is mounted in a rotating spindle whose spin axis is perpendicular to the pivot axis of the bar. A special type of such a pendulum is pivoted through its center of gravity and is called a "balanced centrifugal pendulum." Fig. 2 is a sketch of a typical application.

In this application the spindle is brought up to a predetermined rotational speed ω, whereupon the pendulum is

SYMBOLS

dm	= element of mass
F	= centrifugal force
I_x, I_y	= principal moments of inertia of pendulum
I_n	$= I_x - I_y$
J	= polar mass moment of inertia of pendulum $= I_x + I_y$
k	= modulus of elliptical integral
K	= value of elliptical integral
KE	= kinetic energy
L	= length of pendulum of negligible thickness
M	= mass of pendulum
P	= product of inertia
T	= torque due to centrifugal force
u	= distance of element of mass dm measured along U axis
v	= distance of element of mass dm measured along V axis
θ	= angle between axis $U-U$ and the pendulum principal axis $Y-Y$
θ_0	= initial position of pendulum principal axis measured from axis $U-U$
ω	= spin speed of rotating spindle

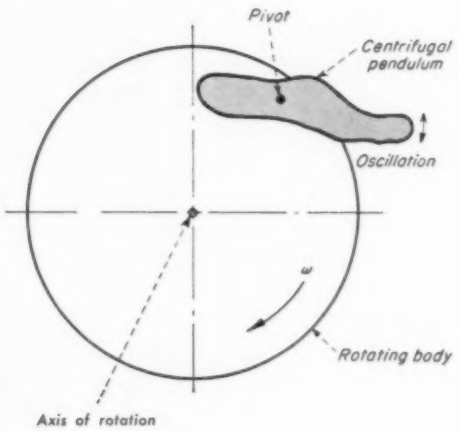


Fig. 1—Most common type of centrifugal pendulum in which pivot axis of pendulum and rotating body are parallel. Pendulum will oscillate about a radial line between pendulum pivot and the axis of rotation.

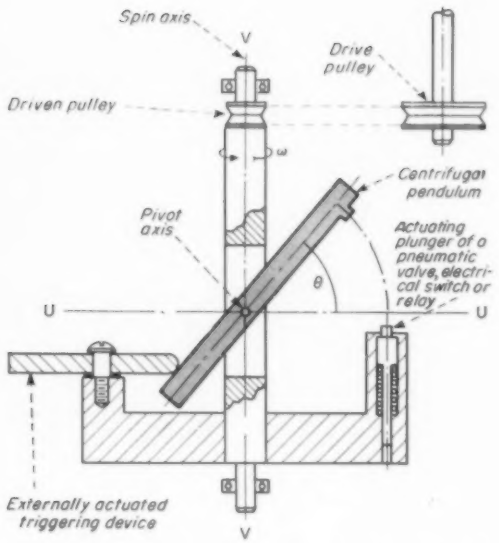


Fig. 2—Typical application of a centrifugal pendulum in which pivot axis of pendulum is perpendicular to axis of rotating spindle. Release of the triggering device permits pendulum to swing toward its neutral plane U-U acquiring kinetic energy which may be applied as required.

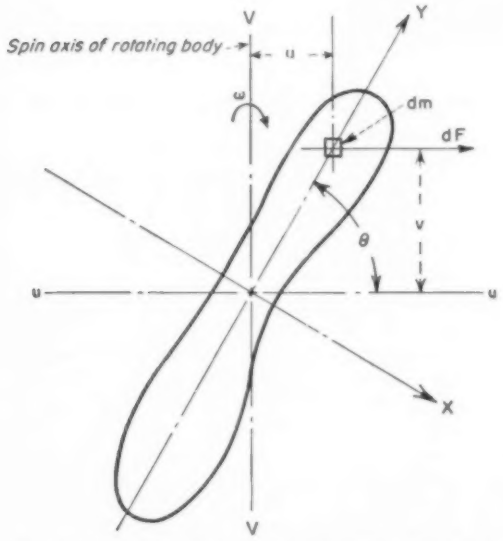


Fig. 3—Pendulum spins around axis V-V. Centrifugal force tends to move pendulum axis Y-Y perpendicular to spin axis.

released by some triggering device. In its initial position the major principal axis of the pendulum is close to the spin axis of the spindle. This position is called θ_o, where θ_o is usually close to 90 deg. Due to centrifugal force, the pendulum when released rotates away from the axis of spin in the direction of decreasing angle θ. If permitted, it will oscillate about its equilibrium position which is $\theta = O$, or 90 deg from the axis of spin. This oscillation could be used as an escapement regulator whose frequency would be a function of spin, and could be applied to a timing mechanism. This simple device can also be used to measure very short time intervals by using the motion of the pendulum during the first ¼ cycle of oscillation. In practice, time intervals of the order of 2 to 200 milliseconds may be attained for shaft rotations of 100 or 10,000 rpm.

When used to perform a function requiring a definite amount of energy, such as compressing a spring, moving a latch rod or closing a switch, the spring or latch rod should be placed close to the equilibrium position of the pendulum (see Fig. 2) where the pendulum has maximum kinetic energy. Energy can then be stored as potential energy in a device such as spring. The pendulum could also be used to rupture a diaphragm which would initiate an action driven by compressed air or to generate an electric voltage by moving a magnet through a coil of wire. Neglecting friction, the amount of kinetic energy acquired is dependent on the spin speed of the housing, the inertia of the pendulum and the initial position of the pendulum.

Since the pendulum is balanced about its pivot axis, timing is independent of any linear accelerations of the spindle. Because of the coincidence of the pivot point and center of gravity of the pendulum, translations of the system cause no turning moments and hence have no effect on the resultant pendulum motion.

At any particular angle θ_o the pendulum will exert torque upon the restraining member. This torque, for a given angle is dependent on the spin speed of the housing and is zero when the spindle is stationary.

Pendulum Torque

Equations for a balanced pendulum mounted in a rotating spindle of general unsymmetrical shape as is shown in Fig. 3 will be derived. Let axis X and Y be the principal axis of the pendulum passing through the centroid of the body. I_x and I_y are maximum and minimum moments of inertia respectively. The pivot axis is taken through the intersection of I_x and I_y which is the center of gravity.

$$dF = (dm)(u)\omega^2 \tag{1}$$

$$T = -\int_{\text{entire mass}} v\,dF = -\omega^2 \int_{\text{entire mass}} uv\,dm \tag{2}$$

By definition, product of inertia is

$$P = \int uv\,dm \tag{3}$$

so that

$$T = -\omega^2 P \tag{4}$$

P may be derived in terms of I_x and I_y and expressed as

$$P = \frac{I_x - I_y}{2} \sin 2\theta \tag{5}$$

combining Eq (5) and (4)

$$T = -\omega^2 \left(\frac{I_x - I_y}{2}\right) \sin 2\theta = \frac{-\omega^2 I_n}{2} \sin 2\theta \tag{6}$$

Applying this equation to a pendulum whose shape is that of a long thin rod of negligible width and of length L, $I_y = O$ and

$$I_n = I_x = \frac{1}{12} ML^2 \tag{7}$$

therefore

$$T = \frac{-\omega^2 I_x}{2} \sin 2\theta = \frac{-\omega^2}{24} ML^2 \sin 2\theta \qquad (8)$$

Another simple shape which is of interest is a cylinder which is pivoted through its axis, in which case $I_x = I_y$ and the torque is zero.

Pendulum Energy

Kinetic energy of the pendulum (relative to the spindle) at any position, neglecting friction, is the work done by centrifugal force on the bar when moving from θ_0 to θ.

$$KE = \int_{\theta_0}^{\theta} T d\theta = \frac{-\omega^2 I_n}{2} \int_{\theta_0}^{\theta} \sin 2\theta \, d\theta \qquad (9)$$

$$KE = \frac{\omega^2 I_n}{2} (\sin^2 \theta_0 - \sin^2 \theta) \qquad (10)$$

therefore

$$KE_{max.} = \frac{\omega^2 I_n}{2} \sin^2 \theta_0 \qquad (11)$$

Pendulum Period

For a conservative system (neglecting friction), kinetic energy may also be written

$$\frac{J}{2} \left(\frac{d\theta}{dt}\right)^2 = \frac{\omega^2 I_n}{2} (\sin^2 \theta_0 - \sin^2 \theta) \qquad (12)$$

and

$$t = \frac{1}{\omega} \sqrt{\frac{J}{I_n}} \int_{\theta_0}^{\theta} \frac{d\theta}{\sqrt{\sin^2 \theta_0 - \sin^2 \theta}} \qquad (13)$$

This is a form of elliptic integral of the first kind and can be transformed to the usual form by substituting

$$\sin \phi = \frac{\sin \theta}{\sin \theta_0} \qquad (14)$$

$$t = -\frac{1}{\omega} \sqrt{\frac{J}{I_n}} \int \frac{d\phi}{\sqrt{1 - \sin^2 \theta_0 \sin^2 \phi}} \qquad (15)$$

to obtain the limits of integration in terms of ϕ note from equation (14) that when $\theta = \theta_0$, $\sin \phi = 1$, $\phi = \pi/2$, and for $\theta = 0$, $\phi = 0$. Therefore

$$t = \frac{1}{\omega} \sqrt{\frac{J}{I_n}} \int_0^{\pi/2} \frac{d\phi}{\sqrt{1 - k^2 \sin^2 \phi}} \quad \text{for} \quad k^2 < 1 \qquad (16)$$

which is an elliptic integral of the first kind where $k^2 = \sin^2 \theta_0$ or $k = \sin \theta_0$.

$$t = \frac{1}{\omega} K \sqrt{\frac{J}{I_n}} \qquad (17)$$

the value of K is found from table of elliptic integrals for given k.

When the centrifugal pendulum has the shape of a thin bar, $J = I_n = I_x$

$$t = \frac{1}{\omega} K \qquad (18)$$

Note that the time delay is inversely proportional to the spin speed of the spindle.

Illustrative Example

Assume that $\theta_0 = 60$ deg, the angular velocity of spindle $\omega = 200$ rad/ sec, the mass of pendulum $M = 0.12$ lb $-$sec.^{2}/in. and $L = 1.0$ in.

$$I_n = I_x = \frac{1}{12} ML^2 = 0.01 \text{ lb-in.-sec.}^2$$

To find the time required for bar to rotate from θ_0 to O deg a table of elliptical integrals gives $K = 2.1565$ for $\sin^{-1} k = 60$ deg so that

$$t = \frac{K}{\omega} = \frac{2.1565}{200} = 1.078 \quad 10^{-2} \text{ sec.}$$

The period T for a complete cycle of the pendulum is four times this value. Eccentricity of the pendulum has little effect on the period. This effect is due only to the frictional torque of the pivot.

To find the maximum amount of kinetic energy available use Eq (11).

$$KE_{max} = \frac{\omega^2 I_n}{2} \sin^2 \theta_0$$

$$= \tfrac{1}{2}(200)^2(0.01)(0.866)^2 = 150 \text{ in.-lb.}$$

To find the torque available at position $\theta_0 = 60$ deg use Eq (6).

$$T = -\frac{\omega^2 I_n}{2} \sin 2\theta_0 = -173 \text{ lb.-in.}$$

In the above analysis pivot friction has been neglected. If it were to be considered then the energy lost to friction would be made up of two parts. The first would be energy lost in pivot friction due to the eccentricity of the bar about the spin axis of the spindle. The second would be the energy lost due to friction on pivot due to the gyroscopic couple.

If the pendulum is used in an escapement, the amount of energy that must be put into the system to keep the pendulum running is four times the sum of these two values per cycle.

EDITOR'S NOTE—A more generalized solution for the determination of the "Response of Dynamic Systems," by W .W. Soroka, appeared in the April 1955 issue of *Product Engineering*, p 150. A simple tabular method permits solution of equations of dynamic systems subjected to complex force functions. By use of the principle of superposition, each specific forcing function is applied to a generalized equation of motion. Periodic, non-periodic, and impulse force functions and their influence on freely and elastically mounted bodies are included with or without the presence of viscous damping.

When more elaborate vibrating systems are encountered a "Simplified Analysis of Complex Vibration Problems," by O. C. Brewster, was published in *Product Engineering*, Nov 1953, p. 161. Based on the fundamental principles of the Mobility Method, the author presents an approach for solving multi-mass and similarly complex problems that retains all of the advantages of the Mobility Method and possesses a few additional ones as well.

It is frequently necessary to find the values of time, velocity and acceleration for the expansion or contraction of a spring. "How Fast Does a Spring Expand?" by J. M. Ramrath, Oct 1953, p 209 presents a simple graphical method of getting this data for both tension and compression springs. It assumes that spring characteristics are known and the spring rate is constant.

Vinyl film 8 mils thick, bonded to steel from which these parts are drawn, supplies color and abrasion-resistant surface eliminating all finishing operations on the part. Film is tough enough to withstand surface abrasion of forming tools; does not craze or separate on sharp-radius bends.

A new wear-resistant surface and colorful finish for metal parts

VINYL Laminate

C. F. KIERNAN, Plastic Development Engineer
and A. J. LOMBARDI, Head, Marvibond Technical Service,
Naugatuck Chemical Division, United States Rubber Company

New adhesive and automatic bonding process — Marvibond — applies a 4 to 20 mil film of polyvinyl chloride to sheet metal; coating is tough and bonding tight enough to take forming and deep drawing without damage or separation from base metal.

USUAL METHODS OF APPLYING protective surfaces to fabricated metal parts involve painting or plating operations for which the thickness of coating has practical limitations. Heavier coatings of several mils or more can be sprayed on when there is a need for greater wear or abrasive conditions, or increased weather or chemical corrosion resistance, but solvents are costly and evaporation is time consuming. Uniform coatings may be difficult to obtain in complex shapes.

Heat stable and chemically resistant coatings of 4 to 20 mils may be obtained at low cost by making parts from sheet laminated on one or both sides with a film of polyvinyl chloride. The lamination process uses a solid film material of better heat and chemical resistance than can be obtained in solution-type copolymer resins suitable for spraying. Film can be applied to the sheet stock mechanically at less cost than spraying, without the problems involved in driving off the solvent.

Major question then is the ability of the laminated surface coating to adhere to the base material, and limitations imposed by various fabricating methods such as stamping, bending, drawing and forming.

● ADVANTAGES

Lower cost than sprayed films

No restriction on forming process

Greater resistance to heat and corrosion

Will not support combustion

Coating may have a wide range of colors, embossed patterns and printed decorations

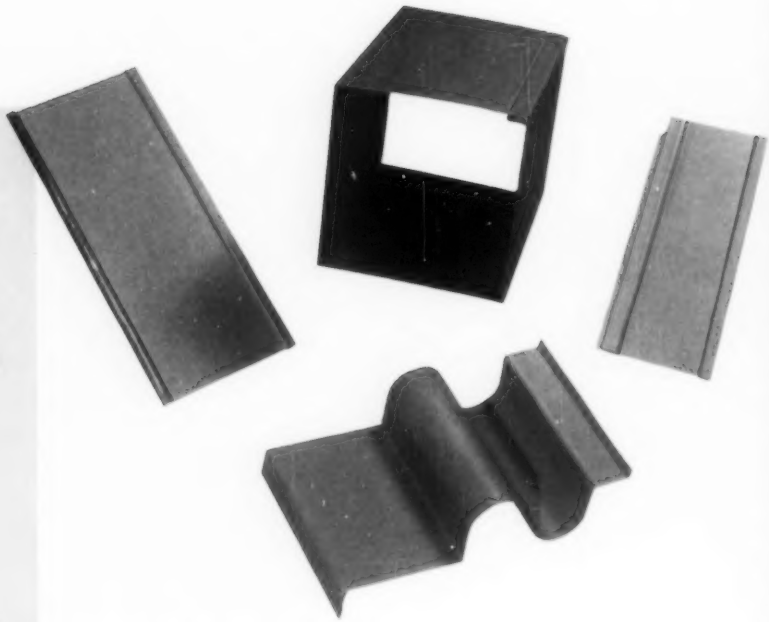
● LIMITATIONS

Service temperature not over 160 F

Welding requires removal of film

Sheared edges require protection

Lubricants for forming must be water-soluble



Usual sheet metal fabricating processes can be used on vinyl-metal laminate without affecting the protective value of the vinyl film.

Properties of Laminate

Recent development of an effective adhesive and a continuous process for bonding sheet vinyl to metal has made available a new sheet material for housings, panels, ducts, cases, luggage, toys and novelties. Some examples of the forming ability of the laminate are shown above. The coating places little if any limitation on deep drawing, blanking, punching and trimming operations applicable to the base material alone. Properties of the film are given in Table I. Base materials include steel, magnesium, aluminum, iron, brass and copper; some non-metallic materials have also been used and work is continuing on applying and testing others.

Humidity will not affect the laminate or the bond. Outdoor exposures for a four-year period and accelerated aging tests have resulted in no effect on the laminate.

Table I – Properties of 8-Mil Film

Tensile strength	4400 psi
Elongation	170 per cent
Tear strength	910 lb per in.
Heat deformation 250 C, 2000 g	32 per cent
Shrinkage, 250 F, with grain	4.6 per cent

Embossed patterns and colors of the vinyl are available in a practically unlimited range, depending on facilities of the laminate supplier. Color can penetrate entirely through the sheet of vinyl or may be applied on the surface only; many multi-color combinations may be obtained including printed and figured patterns. Increased mar resistance of the film surface can be obtained by top coating before laminating. Laminate can be produced with vinyl on both sides.

Forming operations successfully employed to date include shearing, punching, drilling, brake-press bending, stamping, roll forming and cold drawing. The deepest draw reported so far has been 4 in. on a 2 in. diameter with 2SO aluminum core. While spinning has not yet been tried extensively, no difficulty has been experienced, nor is expected.

Draft on deep draws is the same as required for the base material alone; clearance of 0.003 in. should be allowed over the thickness of the laminate. Lubrication during forming should be of the water-soluble type; a water rinse will then clean the surface of the vinyl.

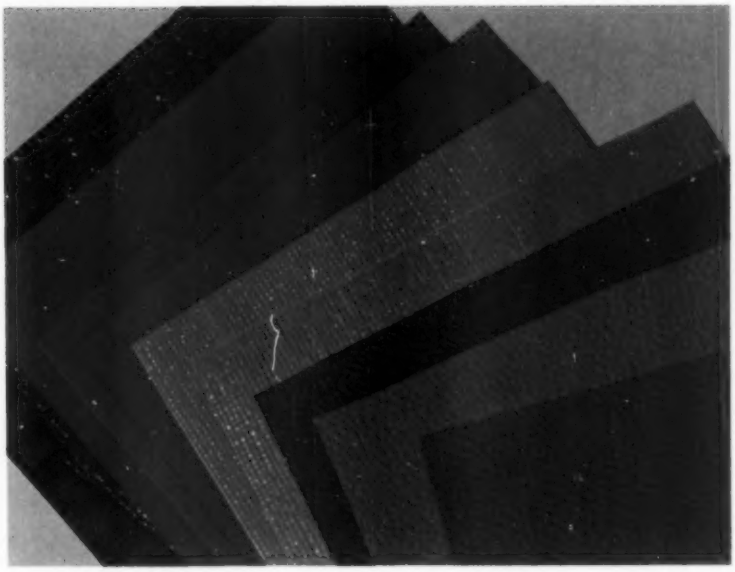
Blanking or piercing operations bare the core on sheared edges. To prevent rust or corrosion or to improve appearance these edges may be painted or covered by inserts or moldings. Where the laminate must be brazed or welded, the vinyl should first be removed around the joints by buffing; for spot welding, an area about ¼ in. diameter is enough. For flash welding against the bare metal side, vinyl coating need not be removed.

Performance Specifications

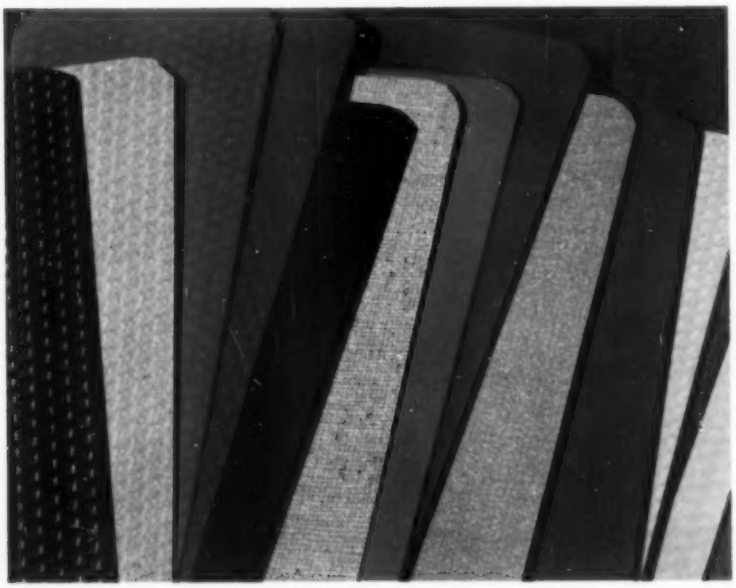
Incoming inspection tests should be set up for pin holes (by 20,000-volt spark test), delamination (visual), adhesion (periodic or spot testing of the laminate), and edges should be examined (visual).

The adhesion test procedure recommended for the laminate is a "peel" test to assure proper adhesion of the vinyl to the core. If the core is metal, the vinyl should tear before the bond gives way; if the core is non-metal, the core should give way before the bond. Definite standards and specifications for the test are now being formulated, and other tests are being worked out.

Vinyl laminate offers good resistance to scuffing and staining, as shown in Table II where it is compared with



Representative colors and textures available in film suitable for coating such sheet metals as: steel, aluminum, magnesium, brass and copper. Film may be imprinted before laminating; embossing after laminating produces attractive surfaces as well as increased stiffness.



other common plastic coating materials tested on the standard Taber Abrader. Resistance to attack from some common chemical agents is reported in Table III. Test specimens were in the form of cups lined with the surface coating; cups were filled with the test chemical and held at 150 F for 17 days or until failure occurred.

Repair of damaged surface is done easily. In most cases, marred surfaces can be touched up with paint of the same color as the vinyl top coat; or small scratches and scuffs can be removed by applying wax to the surface and rubbing it down. Where the vinyl surface is damaged, the section can be easily replaced. After cutting out the damaged piece, adhesive is applied to both the core and the replacement and allowed to dry. Then the adhesive on the vinyl is softened with solvent and pressed onto the core material.

Table II – Abrasion Resistance of Coating

(Tabe Abrador with CS-10 wheel)

Surface Finish	Revolutions per mil
Vinyl laminate	2100
Phenolic	1000
Vinyl lacquer (spray)	400
Urea-alkyd	72

Editor's Note

Selection of finishes for products subject to hard usage has been discussed in several articles in earlier issues. For example, a recent general review "Paint Finishes," May 1955 page 161, deals with paints for special applications and cites several examples including finishes for tractors. A companion article on "Phosphate Finishes," April 1955 page 190, discusses the importance of surface preparation in service life of painted films. Another review "Paint Specifications for Metal Products," March 1954 page 173, includes recommendations covering eight classes of industrial products, and a tabulation of the properties of a number of resins.

Data on chemical resistance of resins and elastomers for coatings are included in "Organic Barriers for Corrosive Protection of Metals," in 1954

Table III – Resistance of Film to Chemical Corrosion

Per cent change in weight in 7 days immersion at 25 C

Sulphuric acid, 60 per cent	−0.07
Sodium hydroxide, 50 per cent	−0.07
Mineral Oil	+0.03
Hydrogen peroxide, 3 per cent	0.22
Lactic acid, 10 per cent	0.24
Nitric acid, 25 per cent	0.40
Acetic acid, 10 per cent	0.46
Ethyl alcohol	1.49
Hydrochloric acid, 10 per cent	1.51
White gasoline	4.82
Phenol-saturated water	20.0
Toluol	30.2
Carbon tetrachloride	40.0

Laminating Process Requires Precise Control

BOND BETWEEN FILM AND METAL strong enough to withstand fabricating and service conditions requires precise control of the laminating process at seven points: cleaning of metal surface; thickness and uniformity of adhesive coating; complete flashing of adhesive solvent; film tension; alignment of film and metal; temperature of material entering bonding rolls; and bonding roll pressure.

Metal Treatment. Metal surface must be chemically cleaned, preferably by alkali cleaning and phosphatizing; zinc phosphate cleaning cannot be employed since any zinc present causes a loss in bond strength.

Thickness of Adhesive. Coating thickness must be held to a tolerance of 0.0005 in., accomplished by carefully controlling the viscosity of the adhesive and the height of squeeze rolls. The adhesive is thixotropic and is applied by spray.

Flashing of Adhesive Solvents. Flashing must be complete before bonding. Temperature and air volume must be controlled since solvents are flammable and toxic.

Alignment of Film and Metal. Alignment is controlled automatically at approximately 10 lb per in. of width. Electronically controlled variable speed drives are required.

Bonding Temperature. The temperature just ahead of the bonding rolls is held in the range of 375-425 F, the actual temperature depending on the thickness and type of metal being coated. Temperature is measured with a surface pyrometer.

Bonding Roll Pressure. Desired pressure must be held constant along the roll length to keep the film from "walking" to one side.

After leaving the bonding rolls the material is cooled below 100 F by water spray or by a combination of water and air blast. When bonding flat sheets, as shown here, the vinyl coating is cut between ends of sheets.

Annual Handbook page C14; also included is an extensive directory of trade names and producers. Properties of colored heat-resistant coatings and recommendations for use on industrial equipment are included in "Colored Silicone Finishes," March 1953 page 167.

"Design for Porcelain Enamelling," 1955 Annual Handbook page C23, includes a brief discussion of protective properties under severe service conditions including exposure to elevated temperatures. Refractory and diffusion coatings for service at 1500 F and higher are described in "Special Coatings for Metals at High Temperatures," January 1954 page 135.

"Zinc Coatings for Protecting Steel," December 1955 page 158, discusses types of coatings for sheet used in formed or deep drawn parts. For data on the effect of wear-resistant coatings on endurance and strength of aluminum parts, see "Mechanical Properties of Aluminum Hard Coatings," September 1954 page 136.

For further data on metallized sheet, see "Metallized Plastic Film," August 1955 page 182.

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FUNCTIONAL DESIGN OF Hydraulic Systems

H. L. Stewart
J. M. Moritz
Logansport Machine Company, Inc.

Application and purpose determine component choice and circuit configuration. How a load is moved establishes cylinder mounting style and service atmosphere may call for rod protection. Force and speed requirements may be translated into pressure, flow and power unit specifications. Desired method of control directs choice of control valves, circuit layout and safety interlocks. Sequencing and synchronization answer specific functional needs of machine action.

PRACTICAL DESIGN of working hydraulic systems includes simultaneous consideration of components, circuit configuration, operator psychology and physiology, mechanical conformation to the parent machine, expected service life and overall economy in first cost and operational maintenance. Best approach to the design of hydraulic systems is from a strictly functional viewpoint. Just what is required in terms of actuating components (cylinders and fluid motors), controls (valves) and source of energy (power unit)?

Reduced to simplest functional terms, suppose an object X is to be moved from a point A to a second point B at a speed of V. Object X will be carried between A and B by a conveyor which is part of the parent machine rather than of the hydraulic system. This method of conveyance, however, will determine several features in the hydraulic system.

Fig. 1 – Cylinder force is here transmitted directly to mounts by lugs on the centerline of force application.

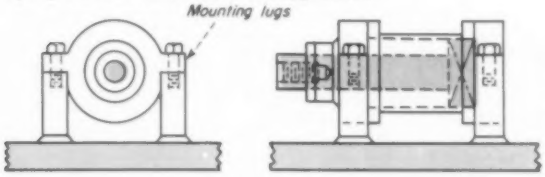
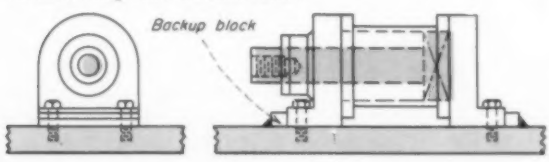


Fig. 2 – Foot mounted cylinder showing welded or backup blocks to help bolts withstand load.



CYLINDER MOUNTING STYLE

If the object is to be pushed in a straight line from A to B, several different mountings are available. Fig. 1 shows a design for centerline mounting in which mounting lugs are in direct line with centerline of thrust. Cylinders of this kind mount well down between the ways of a machine bed. Placing keys behind and in front of the lugs allows full force, both in pushing and pulling, to be distributed over the broad surface of the keys and reduces shear stress on mounting bolts. Back-up blocks are often used in place of keys. These are usually pinned and then welded in place.

A foot mount is shown in Fig. 2. While this is the most popular mounting among cylinder users, a certain amount of torque is created by the eccentricity between the centerline of thrust and the bottom of the mounting foot. It is recommended that keys or backup blocks be used with these cylinders.

Several flange mounted cylinders are shown in Fig. 3. Cylinders are available with a front flange (a), a front

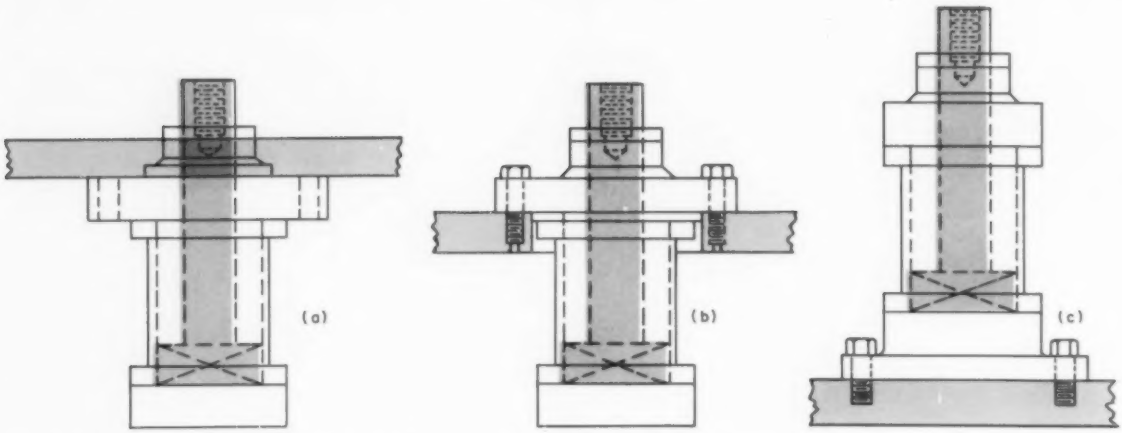


Fig. 3 – Three flange mounts; (a) front flange, (b) reverse flange, (c) blind flange.

flange with reverse mounting (b) or a blind flange mount (c). If the front end of the cylinder is to be piloted and the remaining part to project back into a machine or through a wall, then design (a) will serve. It must be remembered, however, that all thrust will be taken by the mounting bolts. If heavy thrusts are anticipated a front flange with reverse mounting is indicated (b). The reverse flange will take the thrust and mounting bolts merely hold the cylinder in place. If the cylinder is to be used as a jack, then blind end flange mounting (c) is ideal providing that there is room for mounting. Here again mounting screws merely hold the cylinder in place.

If object *X* is to be moved from *A* to *B* in an arc the cylinder must be mounted to permit some rotation. Fig. 4 shows a blind end pivot mount. Rod end and bearing connect to object *X*. The pivot connection on the blind cover is mounted to a clevis bracket that is solidly held as it is depended upon to take the entire thrust. The clevis pin takes the thrust in shear. Fig. 5 shows a trunnion mount where short coupling for pivot action is desired. The trunnion pins are nested into a broad support to give the cylinder added stability to take extra heavy loads and side thrusts without damage to the mountings.

ECCENTRIC LOADING

While concentric loading presents no particular problem, eccentric loading can be a source of difficulty. To compensate for eccentric loading, cylinders may be designed with extra long pistons and rod bearings to take side thrust. Spacer sleeves between the piston and front cover may be used to limit piston travel and give longer bearing support. Some very eccentric loads may require that outboard rod guides be designed into the machine for extra support. Failure to provide suitable bearings or supports will shorten cylinder life. Fig. 6 shows a cylinder design often used to combat eccentric loading.

A number of maintenance problems may be caused by eccentric loads when cylinders are not designed for them. There will be considerable wear on packings due to side thrust of piston rod. Packings may even be scored resulting in excess leakage of hydraulic oil. The piston rod may be bent or badly scored. It is not unusual for large diameter piston rods, even 5 and 6 in., to be bent under eccentric loads. Once bent the cylinder is useless.

A badly scored rod will cut deep grooves in packing and in bronze or cast iron rod bearings. Material torn away from bearings will work its way into the interior of the cylinder which can cause damage throughout the system. These small particles may even jam into the piston and foul piston rings.

Under eccentric loading a cylinder tube is likely to be badly scored along its full length. Excessive side thrust is transferred from the rod to piston and any chipping of piston or breaking of piston ring will cause small particles of metal to wedge between piston and cylinder wall. Scored cylinder tubes are usually beyond repair since they are seldom discovered before excessive damage is done. Excessive friction greatly reduces cylinder efficiency. Cylinder pistons have actually stalled because of friction resulting from eccentric loading.

If points *A* and *B* are separated by several feet it is important that the rod end be adequately supported. A piston rod of any length is heavy enough to sag under its own weight. For example, a 5 in. diameter piston rod, 15 ft. long will weigh 1001 lb. Its effect, without proper support is the same as if there were eccentric loading. The rod support does not have to be anything fancy – just a good solid guide. Fig. 7 shows one simple rod end support method.

Extra long stroke cylinders need additional center support. These supports should not exert excessive clamping pressures or the tube diameter may be reduced enough to cause the piston to freeze when it enters this portion of the tube. Fig. 8 shows one method of tube support.

ATMOSPHERIC PROTECTION

If the machine or process in which a cylinder will be used is dirty or the atmosphere is damp, a piston rod will require extra protection. In dirty atmospheres a protective covering may be used on the rod. This is usually made in the form of a collapsible boot, Fig. 9. Materials used are leather, duck or rubber. Leather boots and duck boots are made in sewed sections, while rubber boots are usually molded. This complete cover keeps dirt and foreign matter from collecting on the rod and scoring it. Another method is to use

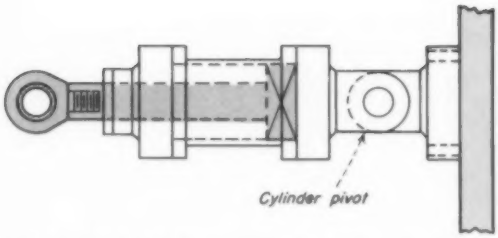


Fig. 4 – Blind end pivot mount. Rod end carries bearing and cylinder pivots on clevis bracket screwed to parent machine.

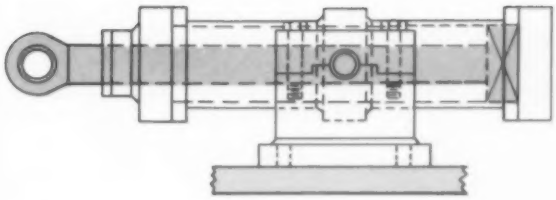


Fig. 5 – Trunnion mount gives maximum support of a pivoted cylinder for extra heavy loads or side thrusts.

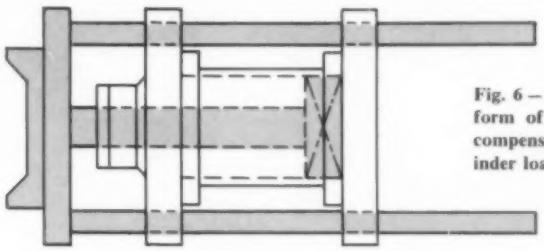


Fig. 6 – Extra support in the form of slide rods used to compensate for eccentric cylinder loading.

Fig. 7–Rod end guide and support for long stroke cylinders to prevent sag.

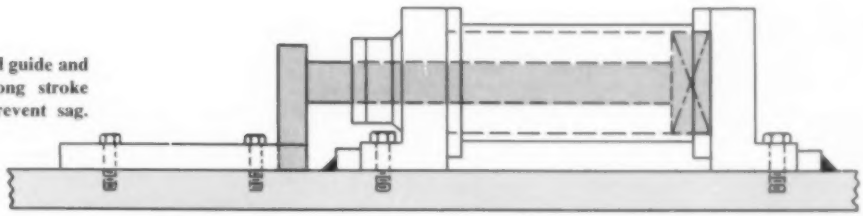
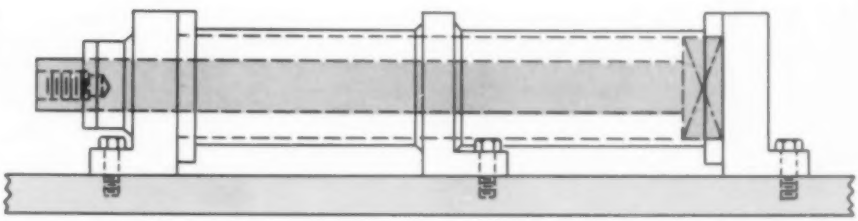


Fig. 8 – Long stroke cylinders need additional support to prevent buckling under load or sag under their own weight.



a hardened rod and a rod scraper, Fig. 10. The rod should be Rockwell C-48 to C-52. The rod scraper, located in the packing gland, scrapes off foreign matter as the rod carries it back toward the packing. The hardness of the rod allows the scraper to do its work without scoring the rod. While scrapers are used on all lengths of cylinders, they are especially advantageous on extremely long stroke cylinders because of their compactness.

In damp atmospheres or where the piston rod is subjected to water, rods of stainless steel or chrome plated steel are used extensively. Stainless steel, while somewhat more expensive, is usually preferred.

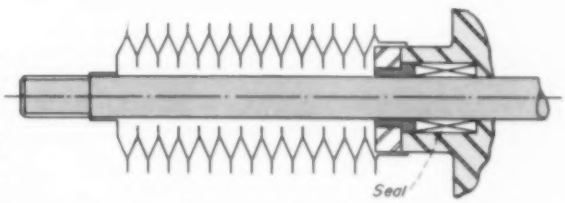


Fig. 9 – Collapsible boot guards rod finish against dirty atmosphere. Collapsed guard length reduces rod stroke.

FORCE AND PRESSURE

The force available to move object *X* from point *A* to point *B* is determined by bore size of cylinder, operating pressure of hydraulic pump, and resistance encountered within the cylinder and from external sources.

Exact efficiency of a hydraulic cylinder is difficult to determine. For all practical purposes most cylinders will run from 90 to 95 per cent efficient and even higher on

larger bores. However, as parts of the system become worn overall efficiency will decrease. Factors affecting cylinder efficiency include piston fits, cylinder bore finish, rod finish and type of packing used for piston and rod seals.

Hydraulic cylinders as standard items are built in pressure ranges from 0 to 250, 750, 1000, 1500, 2500 and 3000 psi. Valves are built in pressure ranges from 0 to 1500, 2000, 2500, and 3000 psi and higher. Pumps are built in pressure ranges from 0 to 1000, 1500, 2500, and 3000 psi. There is no hard and fast rule for determining which pressure range to be used but there are considerations that may help in this decision. At lower operating pressures leaks, excessive heat, and high rate of wear on packings are less likely. Lower pressure components are cheaper and more readily available from more sources. At higher pressures components are more compact and less fluid is required.

A low pressure cylinder would hardly be used to operate a roll-over device in a steel mill because the bore size required would be so large as to make it impractical. A hydraulically operated hospital bed, however, wouldn't include heavy duty mill type cylinders which are costly, heavy and rugged in construction.

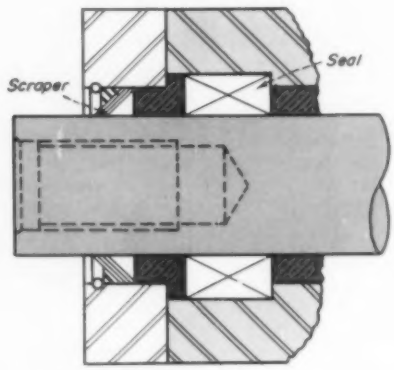


Fig. 10 – Rod scraper cleans hardened rod before it enters cylinder packing.

SPEED AND FLOW

Pump delivery divided by area of cylinder bore determines theoretical speed at which the piston will travel on its out-stroke. On the in-stroke of the piston, speed will be higher because of lost area taken by piston rod. To speed up return strokes two-to-one rods are often used reducing available area of cylinder by half. A two-to-one rod has a cross section area one half the area of the cylinder bore. While two-to-one rods are used on many applications where a fast return stroke is desired, they are also used where extra heavy support is needed as on long stroke cylinders.

Cylinder design is often dictated by required piston speed. For example, pipe ports in cylinder covers are necessarily larger where extra high speeds are required of pistons. If a two-to-one rod is to be used for high speed return of the piston the pipe port in the blind end of the cylinder must be extra large to disperse oil as it is forced out on the return stroke. If neglected, an undersize port will result in loss of speed, back pressure, and creation of heat, all of which are undesirable in a hydraulic system.

When pistons travel at high speeds under high pressure the end covers must be of heavier design and of stronger material than on cylinders operating at low speeds and low pressures. It is preferable that pistons do not contact covers at either end of the stroke. External stops are recommended though they are not always feasible.

Where the piston contacts covers under high speed and pressure, covers must be extra heavy, and cover mountings well anchored. They will be stopping a piston as well as a freely moving body to which the piston rod is attached.

A cushioning device in the cylinder covers is desirable for reducing shock at the end of piston travel. Oil is trapped between piston and cover and exhausted slowly to reduce shock. An ideal cushion would be one which would decelerate the piston from full speed to zero without shock and in a very short distance. A cushioning device should not be used as a flow control. Note that a cushion is of no value whatever if full stroke of the cylinder is not used.

Two general classifications of cushioning devices are built into the cylinder covers; adjustable cushions and non-adjustable cushions. Speed of cushioning can not be changed for non-adjustable cushions without dismantling the cylinder. Leakage between the cushion nose or collar and the cushion bushing or recess in the cover determines how fast oil is exhausted. Fig. 11 shows a non-adjustable cushion.

In adjustable cushions a cushion adjusting needle valve controls flow of exhaust oil after it is trapped between piston and cover. Fig. 12 shows one of the more common types of adjustable cushions. Note taper on the end of the cushion nose to give it ready access to the cushion recess. When nose enters recess, oil is forced through the orifice controlled by the cushion needle.

Cushion noses or cushion collars of standard designs are usually one to one and one-half inches long. Certain applications make these lengths totally inadequate. This is especially true on long stroke cylinders traveling at a high speed, under high pressure and moving a heavy load. It is often necessary to use cushions up to seven or eight inches long. Design of these long cushions may be very different from normal design. Fig. 13 shows three designs of long cushions. Fig. 13(a) shows a cushion with a long taper which gradually chokes off escaping oil until the full diameter of cushion completely cuts off the oil flow. Oil that remains trapped between piston and cover is forced out through the orifice set by a cushion needle.

Fig. 13(b) shows a long straight cushion with a small radius on the end to assure ease of entering into cushion bushing. A tapered Vee groove is cut from the end of the cushion to within a half inch of the piston. This type of cushion works extremely well on cylinders moving a very heavy load at high speeds, especially if this load is on wheels, bearings or rollers. The load decelerates as the orifice in the cushion becomes smaller and smaller. When the end of the orifice is reached trapped oil is forced out through an orifice created by the cushion needle. Fig. 13(c) shows a cushion that has a number of holes in the side of the cushion. As each hole passes into the cushion bushing the total area of the holes is reduced. When the last hole is closed off the remaining oil must escape through cushion needle orifice.

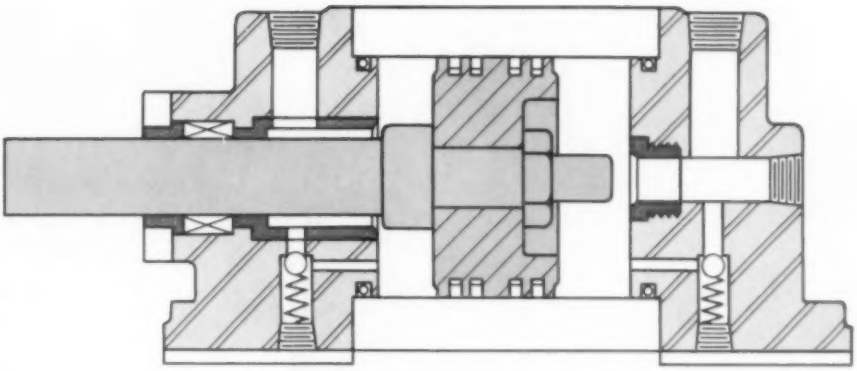


Fig. 11 – Non-adjustable cushion goes into operation when collar enters cushioning chamber. Oil is forced through a restriction raising pressure on the back end of piston to slow its speed.

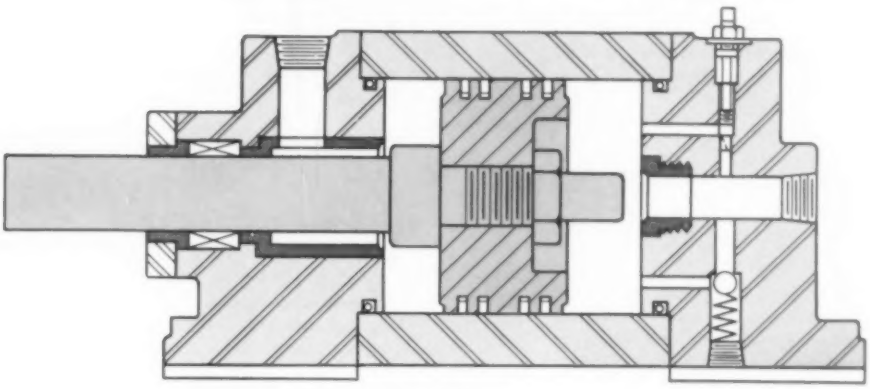


Fig. 12 – Adjustable cushion provides a variable orifice needle valve to control flow of trapped oil. To aid start of piston travel out of cushion a ball check valve permits entrance of pressurized oil to piston face.

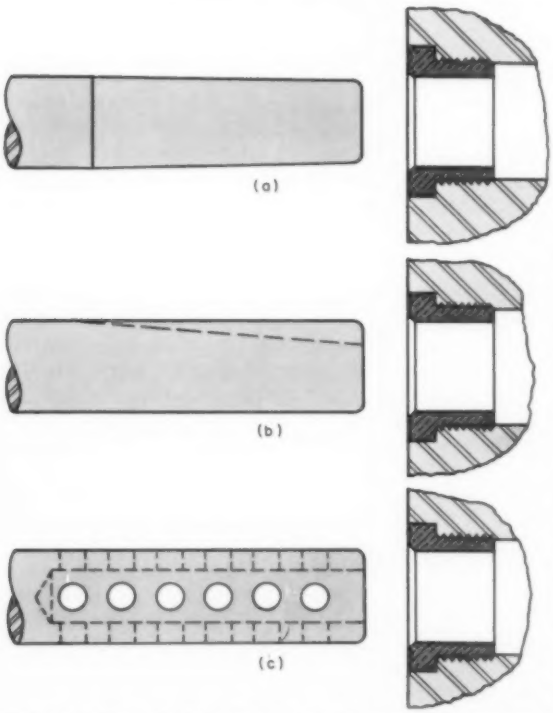


Fig. 13 – Three methods of long stroke cushioning of heavy loads at high speeds. Oil passage area out of the cylinder is slowly reduced to provide shockless stopping.

A cushion adjusting needle must be properly set at all times. Since fit between cushion and cushion bushing is close, if the cushion adjusting needle closes off the orifice completely, a sudden shock will be created when oil is trapped between piston and cover. Different needle settings are required for each load and speed if satisfactory results are to be expected. Two cylinders of the same bore and stroke, doing the same job will probably require different needle settings since any variation in internal leakage past piston or past cushion will change the requirements of needle setting.

The ball check used on all cushions may be called a "starter" for the return stroke, when oil is forced into the cylinder cover through the pipe port the cushion would block off free entry of oil to cylinder. Oil pressure is usually not high enough to move the cushion which has a relatively small exposed area, therefore, some other means of entry must be provided. Oil unseats the ball check and flows to the piston. As cushion leaves bushing full amount of oil can flow through the bushing to move the piston at a rapid rate. The ball check must be of sufficient size so that enough oil will quickly flow through its orifice and get the piston started, otherwise there will be a noticeable increase in speed as cushion nose leaves bushing.

Some recent developments eliminate ball checks by making use of a depressible bushing. This bushing is made of a synthetic material which will seal when pressurized from

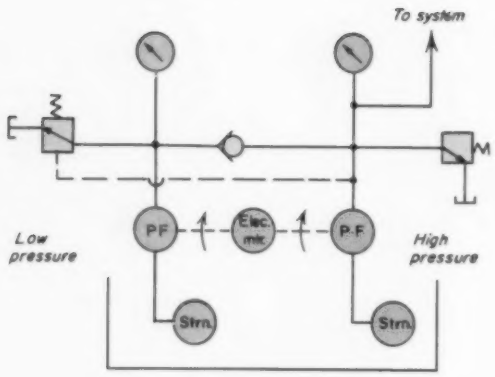


Fig. 14 – Combination power unit provides two pumps with different pressure and volume ratings. When resistance to flow is encountered low pressure pump dumps its flow to tank and high pressure pump takes up the load alone.

Fig. 15 – Cold drawn seamless steel tubing in a steel fitting. Logansport Machine Co.

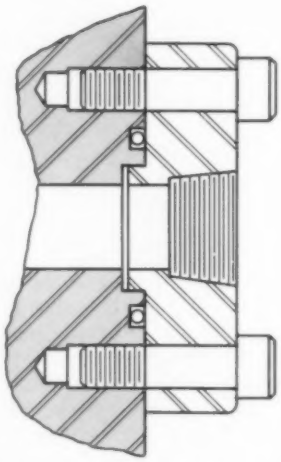


Fig. 16 – Flanged pipe fitting with O-ring seal. Pipe may be screwed or welded into this flange.

one direction but will depress and allow oil to flow freely when reverse pressure is applied.

POWER UNITS

Having established operating pressure, cylinder bore size and piston speed, a power unit must be chosen to match flow and pressure requirements. Power units will be rated in gallons per minute of pump discharge at a certain operating pressure such as 33.5 gpm at 1000 psi. A power unit should be chosen that is capable of delivering somewhat more fluid and at higher pressure than what calculations indicate. After the system has been in operation for some time internal leaks are bound to develop and reserve power will be required to satisfactorily perform the operation. In addition, machines are often required to run faster or with higher loads than those for which they were designed in order to increase production. These emergencies are so common that additional capacity is always worth the cost.

A power unit consists of pump, electric motor coupled to pump by flexible coupling, oil reservoir with baffles and oil level gauge, reservoir cover which may act as pump and motor mounting plate, an intake strainer or filter, a relief valve, a pressure gauge, and the necessary internal piping.

Pumps are of two general categories; constant displacement and variable displacement types. In simple circuits the constant displacement pump is preferred. Vane and gear pumps are most commonly used for pressures up to 1000 psi. They are less expensive than other types and have few operating parts. Gear pumps may have spur, herringbone, spiral or helical gears. Vane pumps make use of both the single and double vane principle. In single circuit applications for industry few hydraulic pumps deliver in excess of 50 gpm.

Combination units answer the need of a low pressure approach at high speed and a high pressure at low speed work cycle. A high-low unit consists of two pumps with a changeover system as shown in Fig. 14. On the low pressure approach both pumps deliver oil to the system at low pressure. When resistance is met the low pressure pump automatically dumps its oil to reservoir and the small volume high pressure pump delivers its oil to the system. The advantages of this system are: (1) Smaller electric motor required and less electric power consumption. For example, a 13.2 gpm single pump operating at 1000 psi requires 10.9 hp input while a 13.1 gpm combination unit operating at 520 psi on fast approach and at 2.4 gpm at 1000 psi only requires a 5 hp motor. However, if full pressure is required for the total length of cylinder stroke the high-low unit is of no value. (2) Less heat will be created since high pressure oil is only being delivered in a small volume.

HEAT EXCHANGERS

If circuit design is such that it is necessary to spill a large volume of oil through the relief valve for any length of time, or if the hydraulic system will be subjected to considerable external heat, a heat exchanger should be added. Oil operating temperature should not exceed 140 to 150 F. Hot oil increases internal and external leakage due to reduced viscosity. It also has a detrimental effect on the life of packing.

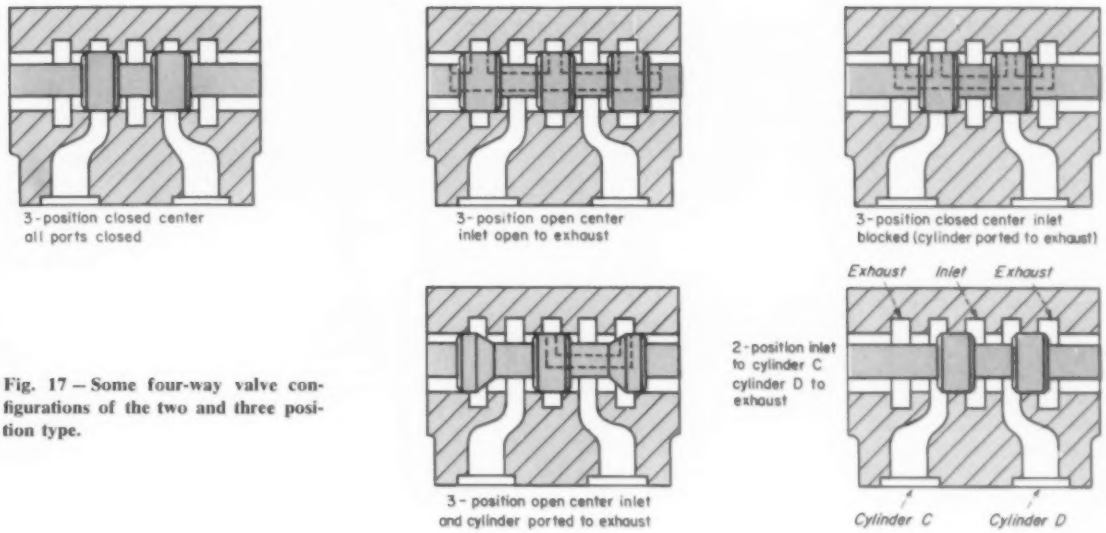


Fig. 17 – Some four-way valve configurations of the two and three position type.

The heat exchanger should be mounted solidly to the side of the oil reservoir in a horizontal position. If system heat is caused by the oil spilling through the relief valve, then the oil should be conducted directly from relief valve to exchanger and then to tank. If heat is caused by some external means then all return oil should be piped through the exchanger and then to tank.

Heat exchangers are usually either single pass or double pass types. Oil should be piped counterflow to the water in a single pass type while in the two pass type oil lines should enter at the same end in which water enters and leaves.

Thermostatically controlled water shutoff valves are desirable so that as operating temperature of oil reaches the proper level, water flow will cut off. When heat increases the water flow will also increase. This conserves water and levels out oil temperature.

PIPING

Piping should be of sufficient size to allow oil to flow with low resistance. Maximum flow rate should not exceed 15 fps, and a flow rate near 10 fps is more desirable. A good rule of thumb to follow when specifying piping is to select the same size pipe as the pipe port of the cylinder.

Number of bends should be kept to a minimum. Bends should be approximately three times pipe diameter. This will reduce oil turbulence and keep oil from changing direction too rapidly.

Hydraulic lines should be as short as possible. Long lines increase friction cost, and create a time lag.

High pressure lines require secure mounting. Bends have a tendency to straighten when sudden surges of high pressure oil flow through lines. Even heavy brackets are occasionally snapped. Addition of a section of high pressure hose or a small accumulator in the line will offer shock protection.

Most commonly used piping in industrial applications is extra heavy steel pipe and seamless steel tubing. SAE 1010 dead soft drawn seamless steel tubing used with steel tube fittings makes an ideal combination, Fig. 15. This tubing is relatively easy to bend and flare. Wall thickness should be such that a safety factor of eight is maintained.

Threads on all fittings and pipe should be Dryseal American (National) standard taper pipe threads.

On extremely rugged applications where large piping is required extra heavy pipe and welded flange type fittings are recommended. Fig. 16 is a sketch of flange and joint. All welded joints should be stress relieved.

DIRECTIONAL CONTROL

Control may be either direct or remote by hand, foot, cam or solenoid actuation. Valves may be of the two, three, or four-way design. The two-way valve has one inlet and one outlet port. When "normally open" the inlet port is connected to the outlet port. When "normally closed" this connection is blocked.

Three-way valves have three ports, an inlet, a cylinder port, and exhaust port. In one position of the valve spool inlet port is connected to cylinder port and in the other position inlet port is blocked and cylinder port is connected to exhaust port. Four-way valves have four ports, an inlet, two cylinder ports, and an exhaust port. Four-way valves are made with two and three position spools as shown in Fig. 17. Note the many combinations available to the designer. Simplest design is that of a two position four-way valve in which in one position of the valve spool, inlet is connected to cylinder port *C* and cylinder port *D* is connected to exhaust. In the other position of the spool the inlet is connected to cylinder port *D* and cylinder port *C* is connected to exhaust.

While the direct acting control valves are less costly and less complicated (except for the direct operated solenoid type) they increase the possibility of external leakage, often require placing the valve at a distance from cylinder, and may require large forces for operation. Since, in a direct

operated valve, it is necessary to form a connection between the valve stem and the actuating means, a packing must be used to seal the valve stem at the cover. While this packing is only subjected to exhaust pressure the packing will eventually wear to a point where leakage will occur. Leakage has been experienced even on new valves due to poor installation (in which valve stems were not properly protected from foreign matter and atmosphere), excessive heat, and from overcured seals.

If it is necessary to place the control valve at a distance from the operating cylinder high pressure piping will be expensive and time lags may be excessive.

Large direct valves even when pressure balanced are fatiguing to operate. This is especially true of large three position spring centered valves.

Remote control systems are somewhat more complicated since a pilot valve operates the master valve. They are also usually more costly. Remote control valves reduce external leakage since spool and spool actuator are enclosed in the main valve. The remotely controlled valve can be placed close to the operating cylinder thus eliminating long sections of piping. Actuators or pilot controls which direct fluid to the pilot connection of the remote control valve require very little operator effort. They can be cycled at a high rate of speed for long periods without ill effects.

CIRCUIT LAYOUT

Schematic diagrams of hydraulic circuits tend to look impossibly complex because of the vast numbers of lines and symbols crowded into a small area. However, they can often be broken down into familiar groups of components interconnected in standard ways to perform functions common to most fluid power systems.

For example, in Fig. 18 a simple circuit is shown which will advance object *X* from *A* to *B* and hold *X* at point *B* for a dwell period before permitting it to return to point *A*. The groups of components in the lower half of this circuit include tank, strainer, pump, motor, relief valve and pressure gage interconnected in a standard circuit configuration.

A three-way manually operated valve controls a single acting cylinder with spring return. When pressure is released from blind end of cylinder spring pressure returns the piston. This circuit functions as follows: Operator shifts

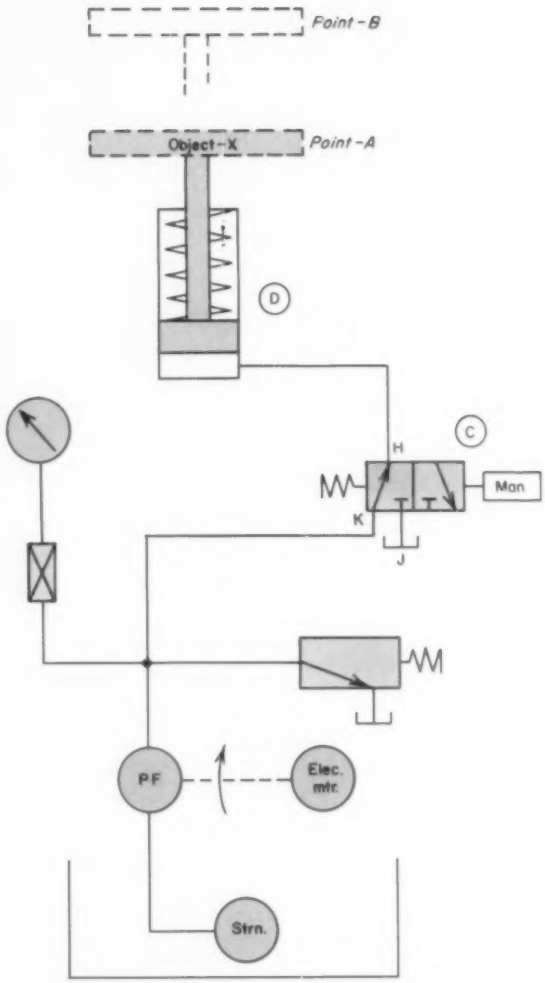
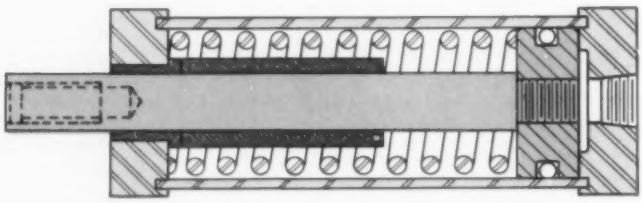
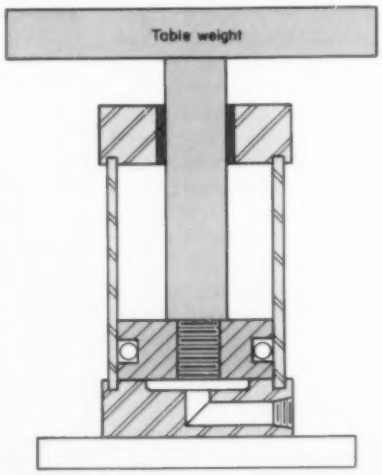


Fig. 18 – Spring return cylinder circuit with manually operated three-way valve. Object *X* is held at point *B* until operator releases valve permitting spring to force piston back to starting point. Pump dumps oil through relief valve on return stroke.

Fig. 19 – Design of a spring returned cylinder and of a gravity returned cylinder. Loose spacer sleeve on rod of spring returned cylinder limits piston travel so that spring does not feel full impact on its closed height at every stroke.





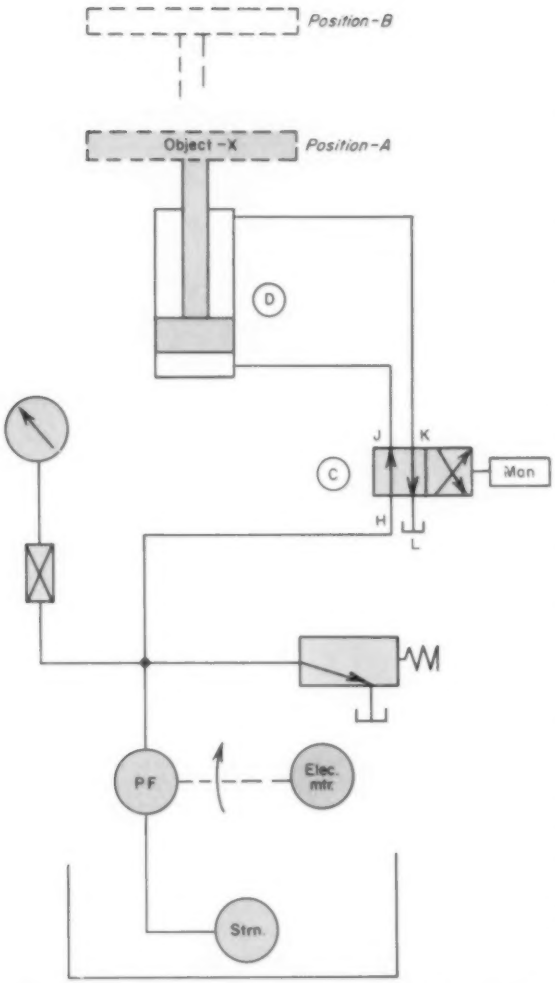


Fig. 20 – Manually operated four-way valve circuit is identical with Fig. 19 except that now piston is returned under oil pressure.

handle of valve *C* allowing oil to flow to blind end of cylinder *D*. Piston rod moves object *X* from point *A* to point *B* at a speed *V*. At point *B* piston of cylinder *D* holds pressure on object *X*. When work is completed operator shifts handle of valve *C* to original position. Spring force pushes piston, which in turn forces oil through port *H* to exhaust port *J* and piston of cylinder retracts. Valve *C*, in the released position, has inlet port *K* blocked.

A three-way valve may also be used as the operating valve with a single acting cylinder of the gravity return type where the weight of piston and associated object *X* are used to return the piston when oil pressure is released.

Use of single acting cylinders with a spring return in hydraulic circuits is not practical if cylinder strokes are long. Too much power is wasted in overcoming spring pressure buildup. This often requires a larger bore cylinder than would normally be used. A cylinder of this type not only requires the length of a double acting cylinder, it requires enough extra length to include the closed height of the spring. Spring breakage and spring fatigue call for additional maintenance. While considerable pressure is developed at the beginning of the return stroke, as the piston travels toward the end of the stroke spring pressure diminishes and the piston slows up. Lubrication is difficult since normally no lubrication is available at the spring end.

On short stroke cylinders spring return and gravity return find many applications. Fig. 19 shows cross sections of a single acting cylinder with spring return and a single acting cylinder with gravity return. Single acting cylinders are also built so that the spring acts on the outstroke and pressure returns the piston. In this design the spring is usually mounted externally on the piston rod.

A four-way valve will apply power on the return stroke and eliminate dependence on spring or gravity return. It may be operated manually, semi-automatically or automatically. Assume application requires that object *X* be moved from *A* to *B* and left at *B* so that the piston can return to move a second object from *A* to *B*.

Using manual control as shown in Fig. 20 operator shifts handle of four-way, two position valve *C* causing oil to flow in port *H* and out port *J* to blind end of cylinder *D*. As object *X* starts its movement from *A* to *B* oil is forced from rod end side of cylinder *D* into port *K* and out exhaust port *L*. Operator then returns valve handle to original position. Oil flows in port *H* out port *K* to rod end of cylinder *D*. Oil is forced out blind end of cylinder to port *J* and out port *L* to the oil reservoir. If there is a standby period of any length when piston reaches end of return stroke, use of a three position valve with an open center is recommended.

By using semi-automatic controls one operator may control two or more machines. He can load one machine and then move to the next. The circuit shown in Fig. 21 functions as follows: Operator momentarily depresses push button on three-way hydraulic pilot valve *C* (as shown) causing oil to flow to pilot connection of valve *D*. Spool of this valve is shifted (as shown) causing oil to flow into inlet *H* and out port *J* on to blind end of cylinder *E*. Oil flows from rod end of cylinder back through port *K* and out exhaust port *L* of valve *D*, back to reservoir. Operator may release valve *C* and leave machine unattended. Spool of valve *D* will remain in position until pressure is applied to pilot *S*. As piston of cylinder *E* reaches *B*, three-way cam valve *F* is contacted and oil momentarily flows to pilot connection *S* of valve *D* shifting spool. Oil in pilot chamber *R* is exhausted through exhaust port of valve *C*. Oil now flows in port *H* out port *K* to rod end of cylinder *E*. Piston automatically retracts to starting position completing last half of cycle without operator.

When using automatic controls the cycle will repeat itself indefinitely. Suppose object *X* is moved mechanically to station *A* and is then to be transferred automatically to *B* as shown in Fig. 22. Object *X* is conveyed to point *A* where limit switch *O* is contacted actuating solenoid *R* of valve *C*. Valve *C* shifts to position shown and oil flows in port *H* and out port *J* to blind end of transfer cylinder *E*. As piston of cylinder *E* moves *X* from *A* to *B* oil flows from rod end of cylinder *E* to port *K* and out port *L* to reservoir. When *X* reaches *B*, limit switch *P* is momentarily contacted energizing solenoid *S* of valve *C*. Spool shifts and oil flows in port *H* and out port *K* to rod end of cylinder *E* and piston

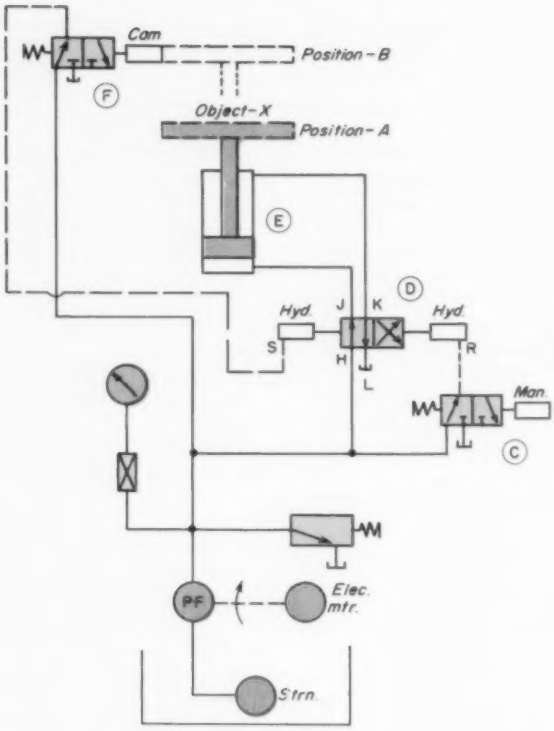


Fig. 21 – Semi-automatic circuit requires operator actuation of pilot valve *C*. Cycle continues, moving object *X* from *A* to *B* and then returns piston to position *A* without further control.

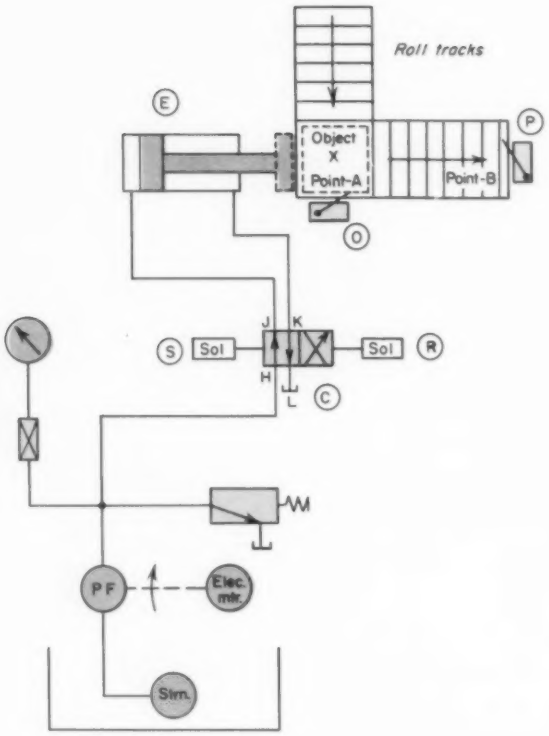


Fig. 22 – Automatic cycle is controlled by limit switches *O* and *P* which start and reverse flow to cylinder. At end of cycle oil spills over relief valve until new object *X* contacts switch *O*.

retracts to starting position. Cycle is complete and it will repeat every time a new object *X* contacts switch *O*.

SAFETY CIRCUITS

Operators are very ingenious in circumventing safety devices to speed up machine operation. On large machines requiring two or more operators, safety circuits can become quite complicated, particularly since all controls must be as tamper-proof as possible.

A press for assemblying a bushing into a casting is shown in Fig. 23. The bushing is object *X*, loading position is point *A* and bushing is to be pressed to point *B*. For operator safety both hands must be occupied as object *X* is moved from *A* to *B*. If either hand is removed from a control the press ram must automatically stop or retract. If either control is tied down the circuit must be designed so that the press will not repeat.

Location of safety controls is important. If they are placed too low, operators may knee one control to have one hand free. Placing controls about shoulder high seems to work out satisfactorily. Here they are above the work table and unlikely to be accidentally bumped. It is suggested that controls be placed back to back about twenty-four inches apart.

Air pilot controls are shown in Fig. 23 to operate the air piloted master control valve. This gives fast action to the controls. Oil pilot controls may also be used to operate the master valve. The circuit functions as follows: Operator loads bushing and casting in press platen. He then depresses push buttons of valves *C* and *D* shifting spools to the shown position. Air flows from regulating filter, and lubricating unit into inlet port *H* of four-way spring offset valve *C*, out port *K*, into cylinder port *V* of four-way spring offset valve *D* and out port *S* to pilot *F*. Four-way three position spring centered valve *E* is shifted to the shown position allowing oil pressure to enter inlet port *O* of valve *E*, leave by port *M* and flow to blind end of cylinder. As the press ram starts to descend, oil will exhaust from rod end and flow into port *R* of valve *E* and out exhaust port *P* to the oil reservoir. If the operator releases valve *C* air will flow in port *H*, out port *L* in port *Q* of valve *D* and out exhaust port *T* to atmosphere. Pressure is released from *F* of valve *E* and the valve spool immediately centers, blocking all ports and stopping downward travel of ram.

If the operator should release valve *D*, instead of *C* air flows from port *K* of valve *C* into port *V* and *Q* of valve *D* into exhaust port *N* from *L* dropping pressure on pilot connection *F* of valve *E*. If the operator ties down either of the pushbuttons on *C* or *D* the press ram will not return.

If controls are operated correctly when valves *C* and *D* are released air flows in port *H* of valve *C* and out port *L* to port *Q* of valve *D*. Air flows to pilot connection *G* of valve *E* and valve spool shifts allowing oil to flow from inlet port *O* to cylinder port *R*. The ram returns to the

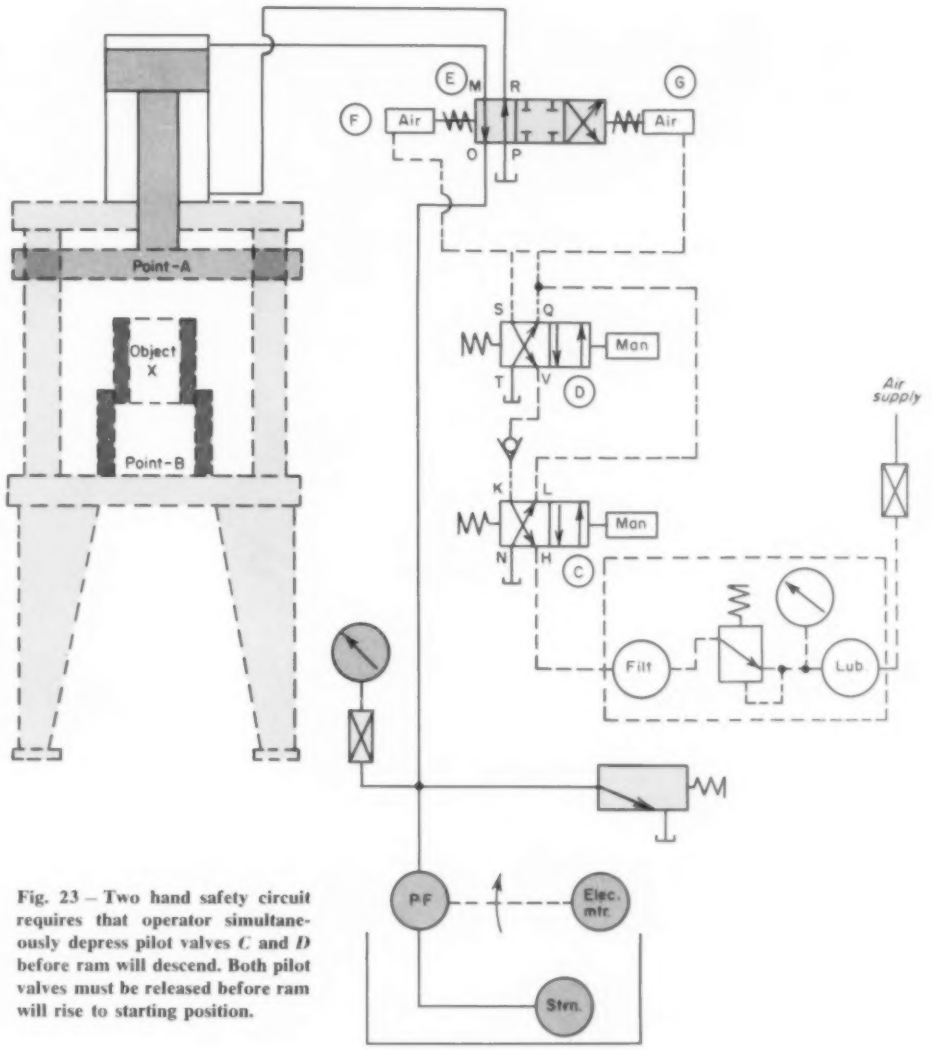


Fig. 23 – Two hand safety circuit requires that operator simultaneously depress pilot valves *C* and *D* before ram will descend. Both pilot valves must be released before ram will rise to starting position.

starting position thus completing the cycle. Note that the ram will not return unless both pushbuttons are released.

Solenoids may be used in place of air pilots in this circuit and set up with spring loaded electrical push buttons.

TWO CYLINDERS

Assume object *X* is to be moved from *A* to *B*, and then from *B* to *C* as shown in Fig. 24. A good example of this is an automatic transfer device. There are several approaches to this problem. Fig. 24 shows the use of sequence valves.

Object *X* moves down power type conveyor and onto platform into contact with limit switch *R*. Solenoid *P* of four-way two position valve *C* is energized shifting spool of valve to the shown position. Oil flows from inlet port *L* out through cylinder port *H* to blind end of cylinder *G* and object *X* is raised from point *A* to point *B*. Oil is exhausted from rod end of *G* through the free flow section of sequence valve *E* back through port *J* of valve *C* and through exhaust port *K* to reservoir.

When cylinder *G* reaches the end of its stroke pressure builds up in the line and overbalances spring pressure in sequence valve *D*. Oil flows through this valve to blind end of cylinder *F*. Ram of cylinder *F* moves forward transfer-

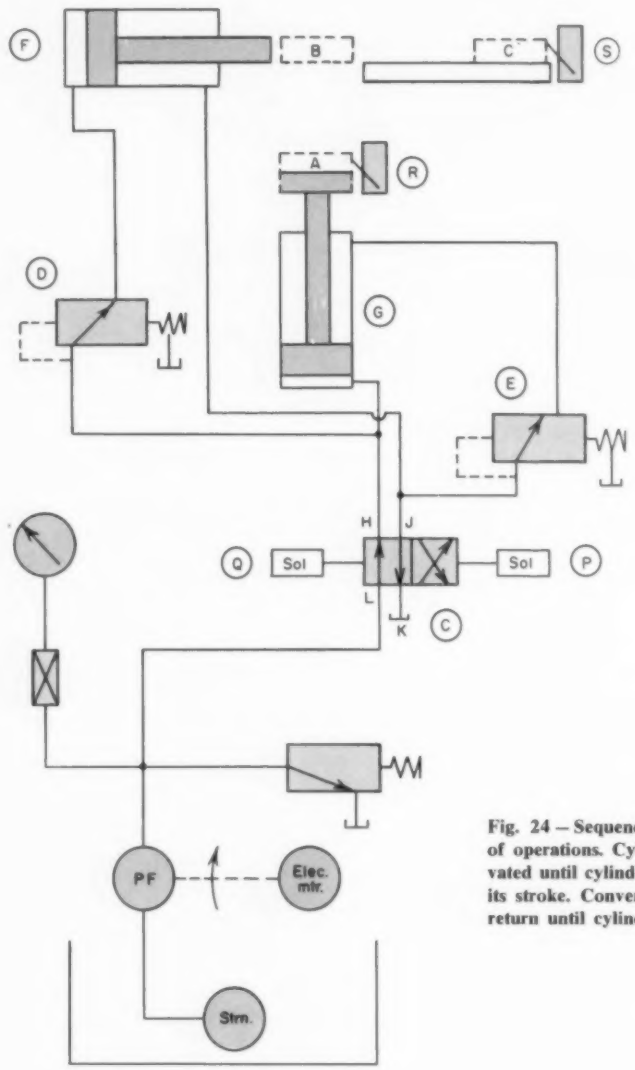


Fig. 24 – Sequence valves control cycle of operations. Cylinder *F* cannot be activated until cylinder *G* reaches the end of its stroke. Conversely cylinder *G* cannot return until cylinder *F* has retracted.

ring object *X* to gravity type roller conveyor. As *X* actuates switch *S* solenoid *Q* of valve *C* is energized shifting spool of valve *C* to starting position. Oil flows from port *L* through port *J* to rod end of transfer cylinder *F* and piston retracts to original position. Pressure builds up, opening sequence valve *E* and allowing oil to flow to rod end of elevator cylinder *G*. As platform reaches point *A* gate is retracted so that next object may move onto platform. At any time platform is not at point *A* the gate will hold back the objects.

Sequence valve *E* can be eliminated in many instances but its use assures that the ram of the transfer cylinder will always return before the platform retracts. This eliminates the possibility of the platform cylinder retracting, picking up the next piece and jamming it into the ram of the transfer cylinder before it has had a chance to fully retract.

There are advantages and disadvantages in using sequence valves to make a sequential movement. Advantages are: (1) Elimination of a second master control valve and provisions for operating same. This reduces cost of the hydraulic system. Two sequence valves will cost about half as much as using another solenoid valve and limit switches. (2) The circuit is more compact. (3) Piping is kept to a minimum in most instances.

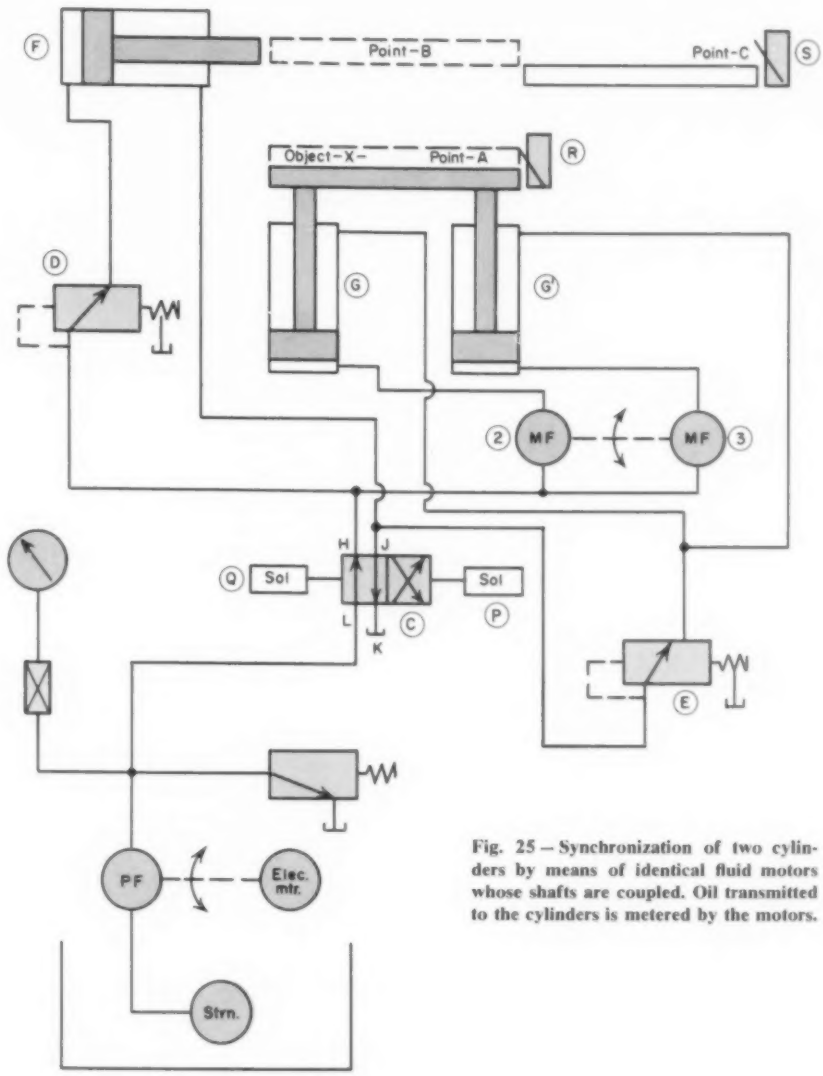


Fig. 25 – Synchronization of two cylinders by means of identical fluid motors whose shafts are coupled. Oil transmitted to the cylinders is metered by the motors.

Disadvantages of using sequence valves are: (1) If some uncalculated obstruction is encountered before the ram of the first cylinder reaches its outstroke then the sequence valve will automatically close and damage may be caused to the workpiece or to the second cylinder. (2) The force required to move the second cylinder must always be higher than that required to move the first. While in many applications this requirement is met, in some instances even a smaller bore second cylinder may be impractical.

SYNCHRONIZATION

A variation of Fig. 24 is shown in Fig. 25. If object *X* is extra long such as a steel beam or a large log then it may be wise to use two cylinders so that the object will be supported at each end. Synchronizing the movement of two hydraulic pistons has many approaches, but few satisfactory solutions. The circuit in Fig. 25 functions the same as Fig. 24 except for the synchronizing means.

In this circuit when spool of valve *C* is shifted to the shown position connecting port *L* to port *H*, oil flows to cylinders *G* and *G'* through two hydraulic motors of the same size whose shafts are coupled. Both cylinders *G* and *G'* receive the same quantity of oil and their pistons will move up together. It should be remembered that nominal

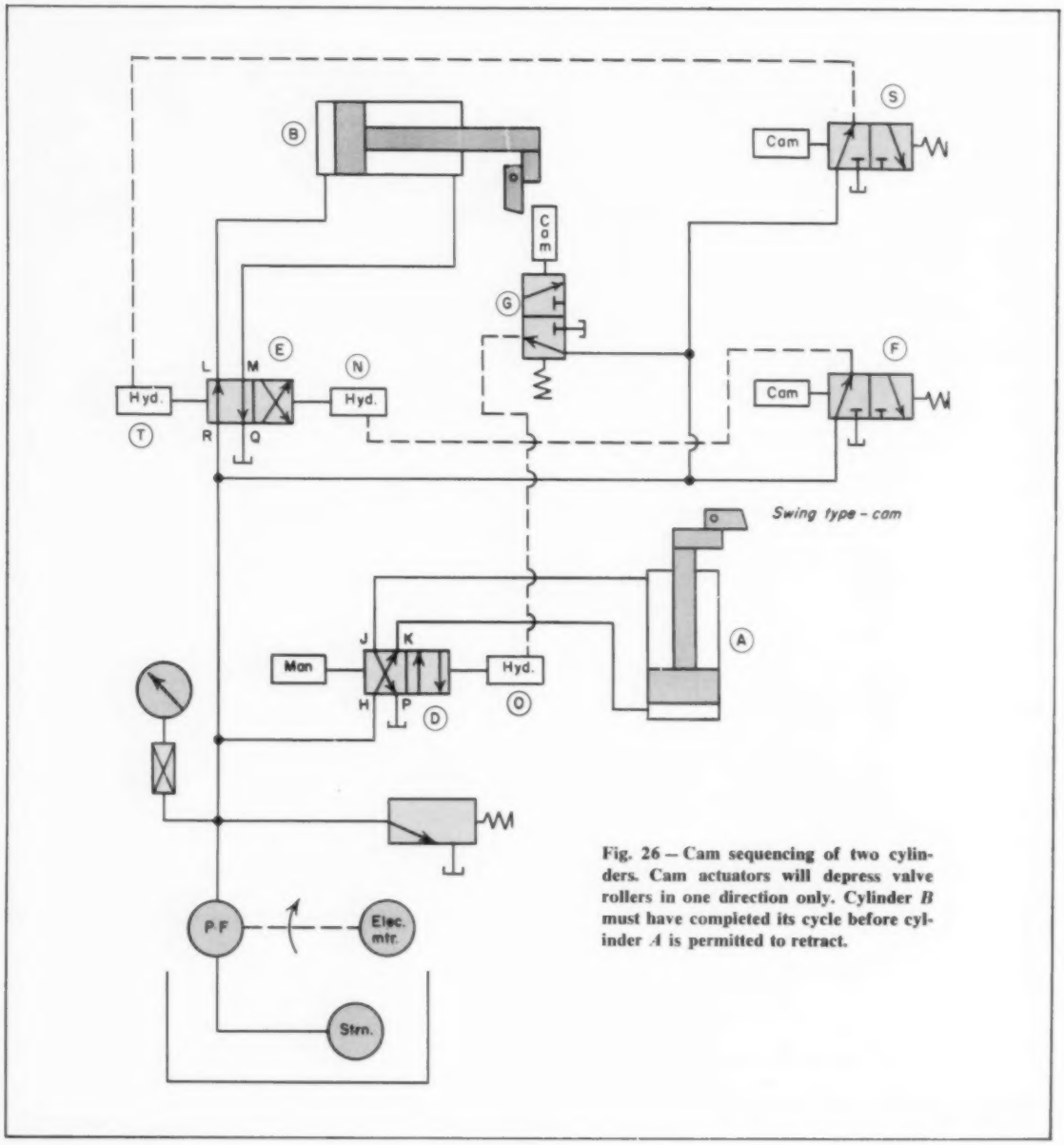


Fig. 26 – Cam sequencing of two cylinders. Cam actuators will depress valve rollers in one direction only. Cylinder *B* must have completed its cycle before cylinder *A* is permitted to retract.

cylinder bores must be the same.

Even this method of synchronization is not perfect but satisfactory in the majority of cases. Leakage past piston may not be identical in the two cylinders. While the nominal bore size of the cylinders may be the same their actual bore size may vary by 0.010 or 0.015 in. due to commercial tolerances of cylinder tubing. Internal leakage and differences in internal passages of the hydraulic motors will also cause some variation. If the synchronization must be held extremely close then components should be selectively assembled and cylinder pistons should have an O-ring or some other piston seal that will not leak. All internal and external leakage must be held to an absolute minimum.

CAM SEQUENCING

Where force required in the first part of a sequence is much greater than that required in the second, a cam sequenced circuit like that shown in Fig. 26 may be used. In this circuit two four-way control valves are the controllers. How automatic the circuit is to be will depend upon selection of controls. In this circuit object *X* is to be extruded by cylinder *A*. Operator shifts handle of valve *D* to position shown allowing oil to flow from inlet port *H* to port *K* of valve *D* and to blind end of extrusion cylinder *A*.

As piston of cylinder *A* moves forward *X* is forced through the extrusion die. Oil in rod end of cylinder *A* flows back through port *J* of valve *D* and out exhaust port *P* to reservoir.

As piston of cylinder *A* nears end of its stroke the cam on the end of its rod momentarily depresses roller of three-way pilot valve *F* which opens the inlet port of this valve as shown and pilot pressure flows to pilot connection *N* of four-way valve *E*. Spool of valve *E* is shifted to shown position allowing oil to flow from port *R* through port *L* to blind end of cutoff cylinder *B*. Oil in the rod end of this cylinder exhausts back through port *M* and out port *Q* of valve *E* to reservoir.

As piston of cylinder *B* reaches end of stroke, cam on end of piston rod depresses roller of three-way pilot valve *S* to shown position. Oil flows from inlet port to pilot connection *T* of valve *E* and piston is shifted reversing flow to cylinder *B*. As piston approaches end of back stroke swing type cam on cutoff carriage momentarily contacts roller of valve *G* as shown allowing oil to flow from inlet through cylinder port on to pilot connection *O* of valve *D*. This reverses flow to cylinder *A* and piston of extrusion cylinder returns to starting position completing cycle.

Solenoid operated valves may be used in place of valve *D* which is semi-automatic and pilot operated valve *E* which is automatic. *F*, *G* and *S* would then be limit switches. To make the cycle completely automatic, a limit switch could be contacted as object *X* is moved into place at cylinder *A*. Use of solenoids usually reduces high pressure piping. Air piloted hydraulic controls may be used in a similar manner.

The circuit of Fig. 26 is positive. The second step of the sequence cannot start to function before the first movement is completed.

It may be desirable to add a cam operated flow control valve to this circuit if the cutoff cylinder piston is required to approach rapidly and then go into a slow feed (if a power saw is being used for the cutoff operation). Flow to cylinder *B* would pass through this valve which is normally open but when the cam roller is depressed by the passing piston main oil flow is shut off and oil passes through an adjustable orifice. Size of orifice controls the feed rate of piston.

There are a number of other sequencing methods. A high-low pumping system may be used where low pressure performs one movement and high pressure the second. Electric motor driven cams trip limit switches or rollers on pilot controls which in turn operate master control valves in sequence.

ROTARY MOTION

Fluid motors may be of the gear, vane, or piston type. Some of their advantages are: They are explosion proof. They have no electrical connections; they can be operated at a wide range of speeds which make them useful on indexing devices. Their speeds may be varied from the maximum to zero by operation of a simple control. They work well on application where variable torque is required. They are capable of withstanding sudden stops and frequent starting and stopping does not harm them. Fluid motors are compact in design and can easily be mounted into a machine element. They can be furnished for flange or foot mounting.

SUMMARY

Whether simple or complex circuits are designed several cardinal principles must be observed. Some were pointed out in the body of this article, others are mentioned here for the first time.

1. Do not overload the system with unnecessary valving.
2. Choose a power device with ample pumping capacity and ample reservoir size.
3. Protect system from possibility of foreign matter entering. The majority of all hydraulic component breakdowns can be attributed to dirt in the system.
4. Specify a good grade of hydraulic oil. The best will be cheapest in the overall picture.
5. Choose system components that are readily available. When a packing wears out or a seal goes bad your customer does not want to wait several weeks for replacement parts.
6. Use manifold mounted valves whenever possible. They can be quickly removed without disturbing piping.
7. Select fluid lines that will pass oil with least of resistance. Keep lines compact as possible.
8. Do not design circuit on the borderline. Eventual internal leakage will reduce its efficiency.
9. Wherever possible select control valves that will allow oil to circulate back to reservoir under zero pressure during long standby periods. This will help keep oil temperature in correct operating range.
10. Select cylinders that will best meet the requirements of the application. There is a great difference in the hydraulic cylinder construction and design.

EDITOR'S NOTE: This article is intended to emphasize the interrelationship of information available to the reader in scattered articles throughout the technical press. Individual articles narrow their attention on one specific aspect of hydraulic design and can provide more detailed information thereby. Following is a chronological list of related articles published in *Product Engineering* for further reference.

"Optimum Pressure for a Hydraulic System," Conrad Cooke, May 1956, p 162. Influence of weight, space, power and load requirements, temperature rise, cost and reliability; a statistical method and charts for comparing and evaluating these factors.

"Pressure Loss in Flexible Metal Tubing," C. M. Daniels, Apr. 1956, p 223. Friction coefficients at high flow rates for corrugated metal hose.

"Oil Reservoir Design," March 1956, p 166. A symposium presenting recommendations of major hydraulic equipment manufacturers on size, rate of flow, baffling, and temperature control.

"Rotating Seals for High Pressure," Harold F. Greiner, Feb. 1956, p 140. Effect of hydraulic balance, structural design, packing and seal face materials on selection of rotating mechanical seals for severe operating conditions.

"High Temperature Seals," T. J. McCuistion, Jan. 1956, p 151. Factors affecting design of glands for sealing reciprocating or rotary motion under extremes of heat and pressure; seal material, gland design, lubrication and surface.

"Quick Disconnect and Self-sealing Couplings for Fluid Application," Dec. 1955, p 168. Seven basic methods for fluid lines requiring frequent separation.

"Measuring Performance of Hydraulic Machines," H. Stern, Nov. 1955, p 150. How to determine input and output power and efficiency from temperature and pressure measurements of hydraulic fluid; methods for measuring rapidly changing temperature.

"Fluid Transmission in High Pressure Systems," Walter Ernst, Oct. 1955, p 135. Amplification of JIC recommendations for use as a guide in the design of industrial hydraulic equipment.

"Hydraulic Pumps," Henry A. Vander Kaay, Ray J. Murphy and William Traut, July 1955, p 132. Relative performance and other factors influencing selection of piston, gear and vane pumps for machine operation and control systems.

"Directional Valves for Hydraulic Circuits," Walter Brown, June 1955, p 186. Available types for starting, stopping, acceleration and direction of control.

"Theory of Hydraulic Flow Control," Nils M. Sverdrup, April 1955, p 161. A detailed analysis of the hydraulic resistance and flow rate of parallel and series circuits and various flow control components.

"Hydraulics for High Horsepower Applications," M. A. Hayden, Feb. 1955, p 129. Factors influencing the design of hydraulic circuits and sample calculations for determining pump and motor sizes.

J. I. C.

HYDRAULIC STANDARDS FOR INDUSTRIAL EQUIPMENT

STANDARD GRAPHICAL SYMBOLS SHALL BE IN ACCORDANCE WITH THE FOLLOWING RECOMMENDATIONS:

(Basic symbols can be combined in any form desired. No attempt is made to show all combinations.)

LINES

- Line, working
- Line, pilot (L > 20 W)
- Line, drain (L < 5 W)
- Line, flexible
- Connector (dot to be 3 x width of associated line)
- Direction of flow
- Line, passing
- Line, joining (tee cross etc) (dot to be 3x W)
- Reservoir (fluid tank)
- Line, to reservoir above fluid level
- Below fluid level
- Manifold, vented
- Plug or plugged connection
- Testing station (gage connection) — S
- Power take-off — PT
- Restriction, choke, fixed viscous
- Restriction, orifice, fixed non-viscous

PUMPS

- Pump, single fixed displacement — PF
- Pump, single variable displacement — PV

MOTORS AND CYLINDERS

- Motor, rotary fixed displacement — MF
- Motor, rotary variable displacement — MV
- Motor, oscillating — MO
- Cylinder, single acting plunger type
- Piston type
- Cylinder, double acting single end rod
- Double end rod

MISCELLANEOUS UNITS

- Motor, drive, electric — ELEC MTR
- Heat exchanger — HE
- Intensifier — INT
- Accumulator — ACC
- Filter — FILT
- Strainer — STRN
- Pressure switch — PR SW
- Pressure gage
- Spring
- Shaft rotating (arrow in front of shaft)
- Component enclosure

VALVE

- Valve, check
- Valve, restriction, choke variable viscous
- Valve, restriction, orifice variable non-viscous — V
- Valve, basic symbol (insert model No. for special valves)
- Method of indicating internal flow

VALVE EXAMPLES

- Valve, manual shut off
- Valve, maximum pressure
- Valve, relief remotely operated
- Valve, sequence directly operated
- Valve, pressure reducing
- Valve, flow control pressure compensated viscous — V (PC)
- non-viscous — V (PC)
- Valve, shut off 2 position - 2 connection
- Valve, directional 2 position - 3 connection
- Valve, directional 2 position - 4 connection
- Valve, directional 3 position - 4 connection open center
- Valve, directional 3 position - 4 connection closed center

METHODS OF OPERATION

- Control, basic symbol
- Control, centrifugal — Cent
- Control, compensator — Comp
- Control, compensator pressure — PR Comp
- Control, compensator temperature — Temp comp
- Control, cylinder — Cyl.
- Control, detent — Det.
- Control, manual — Man.
- Control, mechanical — Mech.
- Control, motor electric — Elec. mtr.
- Control, motor hydraulic — Hyd. mtr.
- Control, pilot hydraulic — Hyd.
- Control, pilot air — Air
- Control, servo — Servo
- Control, solenoid — Sol
- Control, solenoid hyd. pilot operated — Sol. hyd
- Control, thermal — Therm
- Control, pilot hyd. differential area — Hyd. diff. — S

Table I — Properties of Mylar Film

PHYSICAL

Property	Typical Value (1 mil film)	Test Method
Tensile Strength	20,000 lb./sq. in.	Instron Tensile Tester
Tensile Modulus	550,000 lb./sq. in.	Instron Tensile Tester
Break Elongation	75 per cent	Instron Tensile Tester
Impact Strength	60 kgm-cm.	Du Pont Falling Ball Impact Tester
Bursting Strength	45 lb.	Mullen
Tear Strength	15 gms.	Du Pont Single Sheet Tear Tester
Flex Life	20,000 cycles	Du Pont Flex Tester @ 25° C
Bending Recovery	43 per cent	Immediate 180° Bend Recovery
Bending Recovery	51 per cent	60 Second Bend Recovery
Density	1.38 gms./cc.	Density Gradient Tube
Area Factor	20,000 sq. in./lb.	Calculation
Refractive Index	1.64 n_D-25° C	Abbé Refractometer

THERMAL

Melting Point	250–255°C	—
Service Temperature	−60 to 150°C	—
Thermal Coefficient of Expansion	15 x 10^{-6} inches/inch/°F	From 70° to 120°F
Conductivity Coefficient	3.63 x 10^{-4} cals./cm./sec./°C	Cenco-Fitch Method
Shrinkage @ 150°C	2–3 per cent	—

CHEMICAL

Moisture Absorption	Less than 0.5 per cent	1 Week Immersion @ 25°C
Hygroscopic Coefficient of Expan.	11 x 10^{-6} inches/inch/ per cent RH	From 20 per cent to 92 per cent R.H.
Moisture Vapor Permeability	110 gms./100sq.m./hr.	Du Pont Moisture Permeability Test
Oxygen Permeability	0.90 gms./100sq.m./hr.	General Foods Tester
Fungus Resistance	Inert —	12 Months Soil Burial
Copper Corrosion	Negligible —	Visual

ELECTRICAL

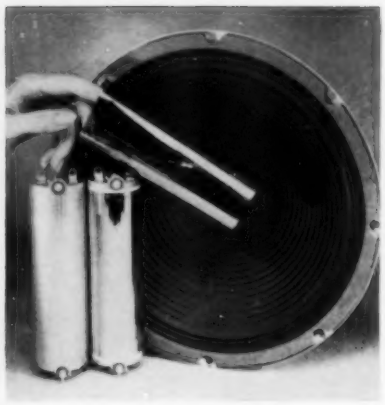
Property	Test Condition	Typical Value (1 mil film)	Test Method
Dielectric Strength	25°C, 60 cycle	4000 volts/mil	ASTM D149-44
Dielectric Constant	25°C, 60 cycle	3.2 —	ASTM D150-47T
Power Factor	25°C, 60 cycle	0.003 —	ASTM D150-47T
Insulation Resistance	100°C	5000 megohm mfds. ("Mylar" 25 C)	Based on wound capacitors
Volume Resistivity	25°C	1 x 10^{19} ohm-cm.	ASTM D257-49T
Surface Resistivity	25°C, 100 per cent R.H.	4.8 x 10^{11} ohms	ASTM D257-49T

MYLAR . . . *A High-Strength Film*

D. D. LANNING
Manager, Sales Development and Technical Service Film Dept., E. I. du Pont de Nemours & Co.

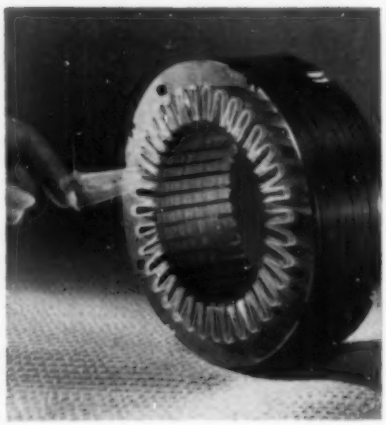
Physical, chemical and electrical properties of a polyester film useful over a wide temperature range; fabrication methods and typical applications.

An outstanding characteristic of this polyester film is the retention of high mechanical strength over a wide temperature range as shown in Table I. It remains flexible and stable from −60 deg to 150 deg C and is highly resistant to many chemical reagents and solvents. Three types of film are available;



▲ THE VIBRATING ELECTRODE of this Philco electrostatic wide-band speaker is made of 0.0005 in. film metalized with aluminum. The thin film keeps charges close together to produce maximum force from a given electrostatic field. Low inertia makes possible high fidelity sound reproduction in the 7,000 to 20,000 cycle range. High tear strength, flex strength and dielectric strength make possible the use of this thin film. The compact cylindrical speaker replaces the unit shown in the background which is not efficient above 10,000 cycles.

▶ A FILM BAND coated with magnetic material is the recording belt of this office dictating machine made by Felt and Tarrant Mfg. Co. Long flex life, high tear strength and resistance to abrasion give the belt mechanical strength. Low moisture absorption, resistance to chemicals and greases and retention of properties over a wide temperature range protect it from environmental damage. The belt won't shrink, stretch or dry out even when exposed to extreme temperature and humidity conditions.



▲ HIGH VOLUME and surface resistivity, high dielectric strength and low power factor led to the selection of this film for slot liners and coil insulation in General Electric motors. High tensile and tear strength permits use of thinner films. Resistance to abrasion and long flex life prevent mechanical damage during manufacture or use. It can be used alone or laminated to other insulating materials. It is resistant to solvents, greases and varnishes, is dimensionally stable over a wide temperature range, and does not absorb moisture.

Table II — Types of Mylar Polyester Film

"Mylar" *A*—A transparent film for general use as an insulation and dielectric material. It can also be used in many industrial applications where a strong, durable material is required.

"Mylar" *C*—A film of high transparency and good high temperature insulation resistance. For use as a dielectric in high temperature capacitors, and for all packaging applications.

"Mylar" *D*—A highly transparent film available in heavy gauges only.

THICKNESS AND YIELD:

Type	Gage	Inches Thick	Sq. In./Lb.	Sq. Yds./Lb.
A, C	25	0.00025	80,000	61.73
A, C	50	0.00050	40,000	30.86
A, C	100	0.00100	20,000	15.43
A	150	0.00150	3,300	10.29
A	200	0.00200	10,000	7.72
D	300	0.00300	6,650	5.13
A, D	500	0.00500	4,000	3.09
A, D	750	0.00750	2,650	2.04

each type is basically the same but with minor modifications to adapt the film to a specific range of end uses. This is shown in Table II.

PHYSICAL PROPERTIES

Properties of Mylar are compared to other Dupont films in the accompanying charts. While values shown are typical and represent tests on the film they are not necessarily minimum design values. Physical properties are compared with those of cellophane, acetate film and polyethylene film in Fig. 1. Tensile strength, tensile modulus, yield point and impact strength are high. The flex life, tear strength and moisture absorption rate are favorable but not as good as for polyethylene film. But yield point and tensile strength are higher than hard aluminum.

It is relatively stiff, with a modulus higher than that of cellophane or acetate film. At the same time, however, resistance to failure by repeated flexing is outstanding. Where the cellulosics can be flexed only a few hundred

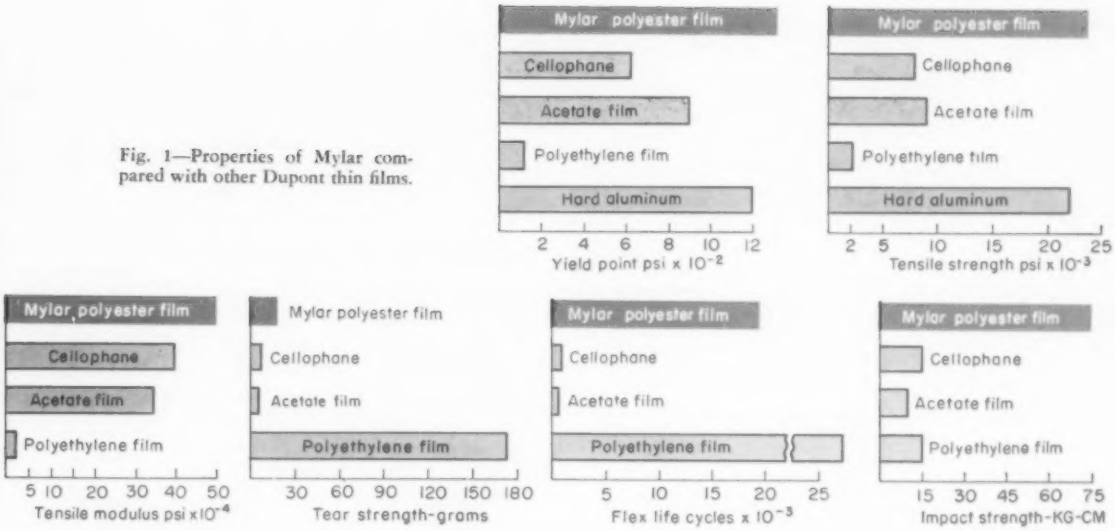


Fig. 1—Properties of Mylar compared with other Dupont thin films.

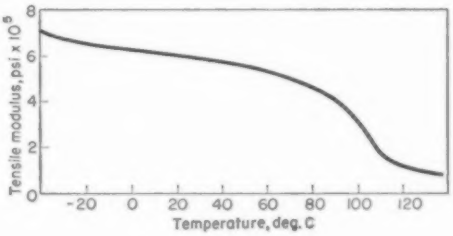
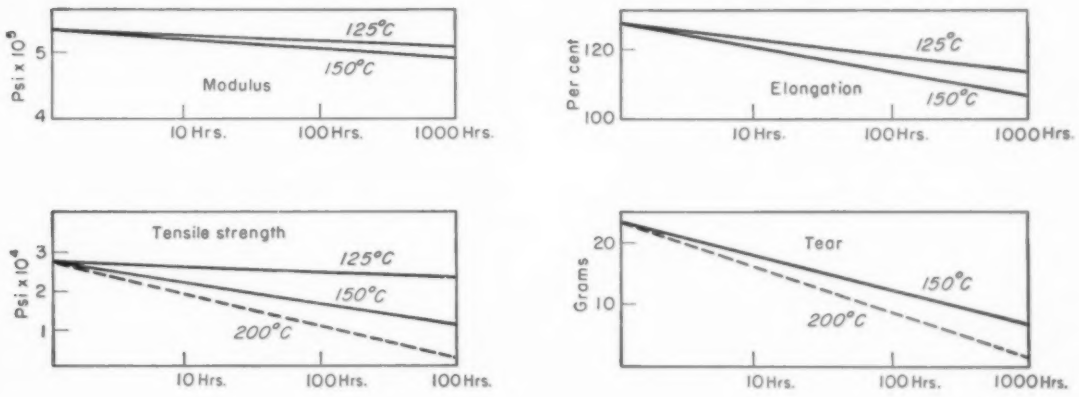


Fig. 2—Modulus decreases as temperature increases, with a marked change at about 100 C.

Fig. 3—How room temperature properties are affected by aging in air at elevated temperatures.



times, 1 mil Mylar can take over 20,000 flexes under identical conditions. The combination of high impact strength, excellent flex life, high stiffness, and good tear resistance gives this film its mechanical durability.

Mechanical properties are retained over a wide temperature range and are stable when exposed to heat for long periods. No embrittlement occurs at temperatures as low as —60 C. The tensile properties undergo marked change at about 100 deg C, but the film retains useful properties at 150 to 175 deg C, as shown in Fig. 2 for the elastic modulus. The melting range is 250 to 255 deg C. No embrittlement occurs at temperatures as low as —60 C.

As shown by Fig. 3, the tensile strength, modulus, elongation and tear strength are not greatly reduced by exposure to temperatures of 125 deg, 150 deg or 200 deg C for periods up to 1000 hr. At high temperatures, the film will shrink slightly with most of the change taking place in the first 10 min. At 150 deg C in air, this shrinkage is less than 4 per cent. Once shrunk, the film

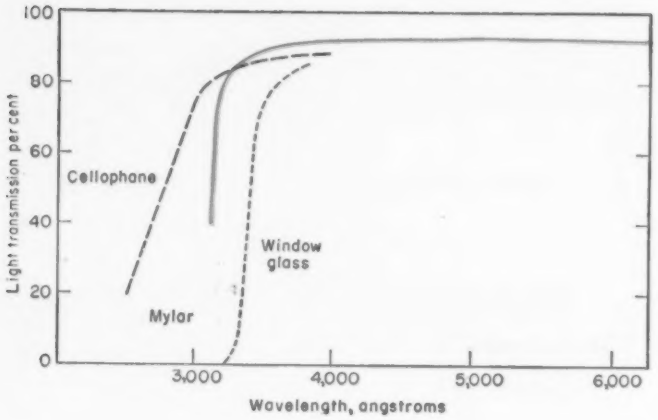
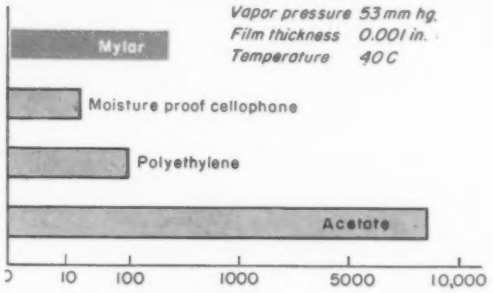


Fig. 4—Comparison of light transmission for Mylar, cellophane and window glass.

Fig. 5—Permeability to water vapor for Mylar compared with other Dupont thin films.



is dimensionally stable on prolonged exposure at or below the shrinking temperature. This characteristic is useful in shrinking the film in place around a component.

When the flammability of the film is determined by procedures essentially conforming with ASTM D568-43, the results are erratic and inconclusive. Samples melt and drip during the test and often extinguish or become separated from the flame. Qualitatively, it appears to burn less readily than cellophane and acetate film.

The light transmission of this film is compared with cellophane and window glass in Fig. 4. The film transmits over 90 per cent of incident light in the visible spectrum and cuts off the ultraviolet light to about the same extent as window glass.

Moisture absorption is less than 0.5 per cent after immersion in water at 25 deg C for 1 week. Physical and mechanical properties are relatively independent of humidity. With constant dry bulb temperature of 24 deg C, the film length changes 0.08 per cent over a range of 20 to 92 per cent R. H. The water vapor permeability of Mylar is compared with that of other Dupont thin films in Fig. 5.

CHEMICAL PROPERTIES

Resistance to many chemical reagents and solvents is shown in Fig. 6. Tensile strength does not go below 50 per cent of the original value although tear strength values tend to decrease at a more rapid rate. The film has excellent resistance, in general, to penetration by solvents, greases and oils. At room temperature, permeability to methanol, ethyl acetate, carbon tetrachloride, hexane, benzene acetone, and acetic acid is essentially zero. At temperatures near the boiling point it is little affected by ethyl acetate, methyl ethyl ketone, naptha and many other chemicals. Oils and greases such as penetrating oil, lard, cottonseed oil and motor oil did not penetrate a 1mil film after exposure for two months at room temperature.

Phenols and cresols tend to lower physical properties. The film will embrittle rapidly under severe hydrolysis. For example, film samples placed in sealed glass tubes with small amounts of mineral acids or water and held at 125 deg C will become very brittle in about 24 hr.

The film resists attack by some common electrical varnishes. Film samples coated with varnishes were baked at 150 deg C for 1 week, then tested for tensile modulus, tensile strength, elongation, tear strength and impact strength. Phenolic resin varnishes and asphaltic base varnishes caused some decrease in impact strength and elongation without affecting tear strength. Silicone varnishes had little or no effect on any of the physical properties. Resistance is also good to "Pyranol", Silicone 200, and hydrocarbon oil of either low or high viscosity index. Only slight changes in properties occurred after immersion for 1000 hr at 100 deg C.

ELECTRICAL PROPERTIES

Mechanical, chemical and electrical properties make the film excellent for electrical insulation. It has a good dielectric constant, high volume and surface resistivity and a low power factor. The dielectric strength of a 1 mil thick section of Mylar is about 4000 volts per mil at 25 deg C and 60 cps. Dielectric strength decreases slightly at higher temperatures, becoming about 3150 volts per mil at 150 deg C. It is also a function of thickness. Film 0.00025 in. thick will have dielectric strengths as high as 7500 volts per mil; a 0.007 in. thick section will exhibit a strength of about 2500 volts per mil.

METHODS OF FABRICATION

Mylar can be vacuum metalized, laminated to other materials, embossed, dyed, printed, and vacuum formed.

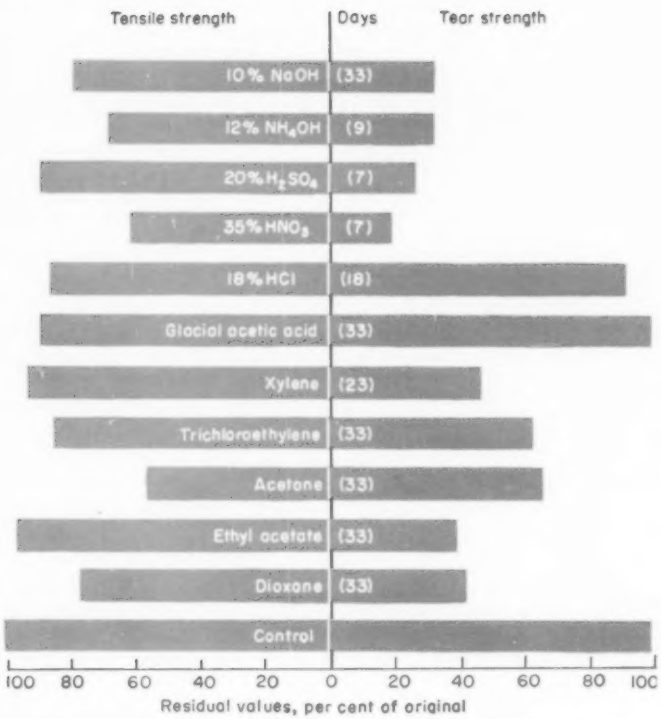


Fig. 6—Chemical resistance measured in terms of change in physical properties introduced by exposure for the number of days shown.

A variety of metallic colors can be created in the metalizing process. One method is coating the film with a transparent colored lacquer before metalizing. Similar effects may be obtained with colored adhesives if the film is bonded to another material. The metalized film is laminated to vinyls, cloth, papers, etc., then embossed in a variety of patterns. Those laminates have a wide range of colors, great strength and high flexibility and abrasion resistance. They will not dry out, embrittle with age or fade and are easily cleaned. Their ability to be shaped around contours and edges makes installation easy, saving time on production lines. (For further data on this coating process see "Metallized Plastic Film", August 1955, page 182.)

Metallic yarns are made by slitting film and aluminum foil laminations into very narrow widths. The yarn is adaptable to tricot and knitting operations, and can be quilled or twisted for use on weaving machines at normal operating speeds. Fabrics containing it may be cross dyed without discoloring the metallic yarn.

The film may be laminated to metals before drawing operations to protect the sheets and avoid lacquering or plating operations. It can be printed with conventional rotogravure and flexographic processes using commercially available inks.

Film may be laminated with the same type equipment used for laminating cellophane to other films, foils and materials. Provisions should be made for static elimination in addition to precautions normally observed in handling other flexible films.

APPLICATIONS

Products using Mylar include many types of electrical insulation, magnetic recording and pressure sensitive tapes, metalized film laminates, thermal insulation and vapor barriers, laminations to wood and metal and many packaging applications.

Laminated to leather, it adds a sheen that lasts indefinitely while retaining the original grain. The laminate is unaffected by mildew and may be spot cleaned without affecting color or sheen. This type laminate is now used for articles such as handbags and shoes. It is also used as a base for metallic yarn, for automobile upholstery and for fabrics which will withstand washing, pressing and dry cleaning.

Laminated to aluminum foil, it produces a vapor barrier for refrigeration insulation, a protective covering for pipe lines and a barrier material for special packaging methods.

As an electrical insulating material, the film can be used by itself, or laminated to other materials. This saves space by avoiding the use of bulkier insulating materials. It may be used on round or rectangular magnet wire, as layer insulation or between transformer coils; it functions as a dielectric in dry and liquid filled capacitors, as slot liner and phase insulation in motors and as tape insulation in field coils. The film has been used as a dielectric and an insulator in modular electronic components.

As a base for tape, it is tough, durable and dimensionally stable. Such tapes do not shrink, dry out or deteriorate when exposed to heat and humidity. Tape made of this film is being evaluated to replace steel strap to bind cartons and pallet shipments.

Laminated to glass fiber panels, it forms easily installed acoustical baffles for sound conditioning. Acoustic tiles are made in similar manner for office and home use.

Because this material can be applied as easily as wallpaper and will vapor seal joints, it is used to line floors, walls and ceilings to control conditions of extreme humidity. Adhesives that are now available allow it to be applied directly on existing walls.

Products ranging from food to textiles are packaged in this film. Its transparency and chemical and physical properties make it adaptable to items with long shelf life. The durability of the film reduces hazards of shipping and storing. Bonded to fiberboard or metal tubes and containers, it may be used for bulk or consumer packaging of products such as shortenings, medicinals, lubricants and corrosive chemicals.

Problems with heat sealing have introduced some difficulties in packaging applications. It cannot be heat sealed with techniques used on other films. However, a method developed using benyl alcohol and heat promises effective sealing on automatic packaging machinery.

Lubrication of Roller Chains

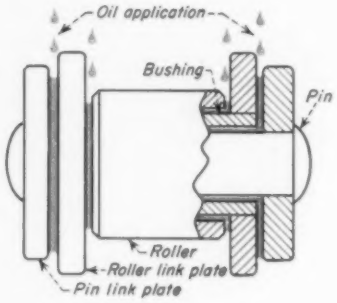


Fig. 1

FIG. 1—*Apply oil* drops between roller and pin links on lower strand of chain just before chain engages sprocket so that centrifugal force carries oil into clearances. Oil applied at center of roller seldom reaches bushing area.

FIG. 2—*Manual application* of lubricant by (A) flared-lip oil can, or (B) hand brush, is simplest method for low-speed applications not enclosed in casings. New chains should be lubricated daily until sufficiently "broken-in," after which weekly lubrication programs should suffice.

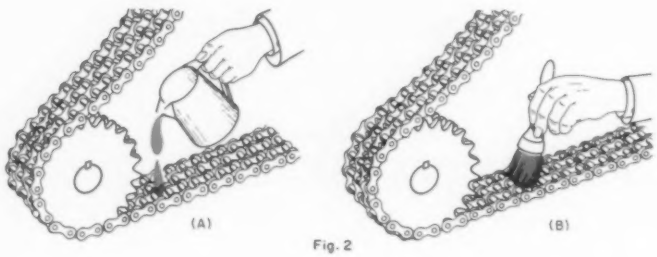


Fig. 2

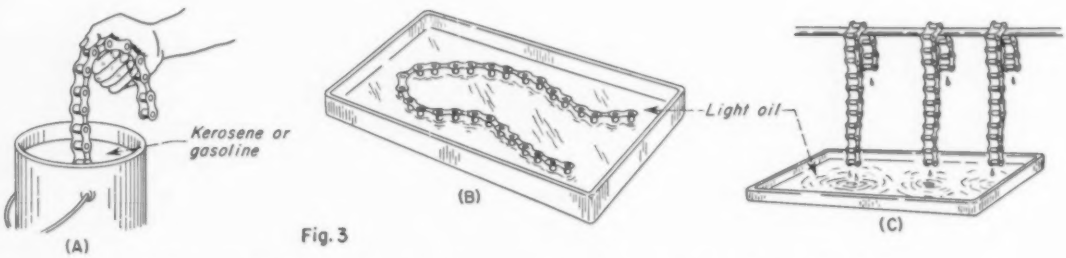


Fig. 3

FIG 3—*Chains without casing* should be: (A) removed periodically and washed in kerosene, (B) soaked in light oil after cleaning, and (C) draped to permit excess oil to drain.

FIG. 4—*Drip lubrication* can be adjusted to feed oil to edges of link plates at rate of 4 to 20 drops per minute depending on chain speed. Pipe contains oil-soaked wick to feed multiple-width chains.

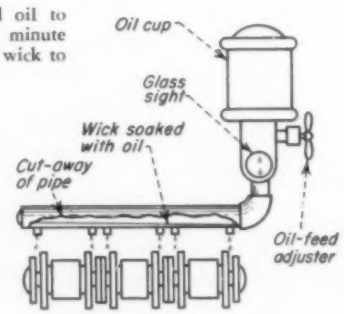


Fig. 4

FIG. 5—*Continuous lubrication* systems for open chains: (A) Wick lubrication is lowest in cost to install; (B) Friction wheel lubrication uses wheel covered with soft absorbent material and pressured by flat spring.

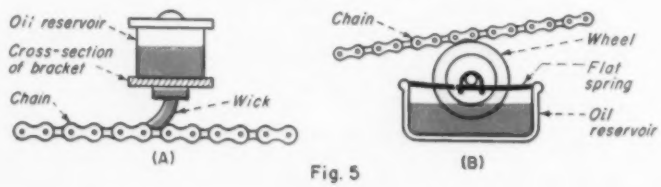


Fig. 5

Unsatisfactory chain life is usually the result of poor or ineffective lubrication. More damage is caused by faulty lubrication than by years of normal service. Illustrated below are 9 methods for lubricating roller chains. Selection should be made on basis of chain speed as shown in Table I. Recommended lubricants are listed in Table II.

Table I—Recommended Methods

Chain Speed, ft/min	Method
0– 600	Manual: brush, oil can Slow Drip: 4–10 drops/min Continuous: wick, wheel
600–1500	Rapid Drip—20 drops/min Shallow Bath, Disc
over 1500	Force Feed Systems

Table II—Recommended Lubricants

Pitch of chain, in.	Viscosity at 100 F, SUS	SAE No.
1/4–5/8	240–420	20
3/4–1 1/4	420–620	30
1 1/2–up	620–1300	40

Note: For ambient temperatures between 100 to 500 F use SAE 50.

FIG. 6—*Shallow bath lubrication* uses casing as reservoir for oil. Lower part of chain just skims through oil pool. Level of oil must be kept tangent to chain sprocket to avoid excessive churning. Should not be used at high speeds because of tendency to generate excessive heat.

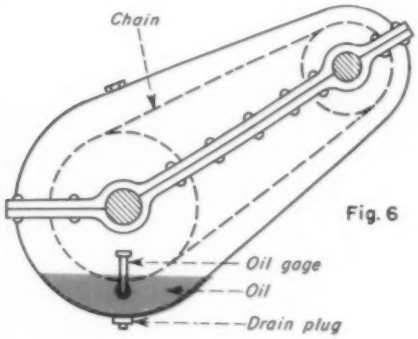


Fig. 6

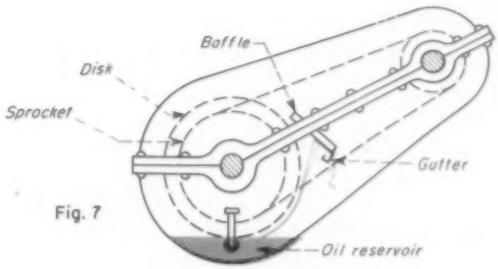


Fig. 7

FIG. 7—*Disc or slinger* can be attached to lower sprocket to give continuous supply of oil. Disc scoops up oil from reservoir and throws it against baffle. Gutter catches oil dripping down from baffle and directs it on to chain.

FIG. 8—*Force-feed lubrication* for chains running at extremely high speeds. Pump driven by motor delivers oil under pressure to nozzles that direct spray on to chain. Excess oil collects in reservoir which has wide area to cool oil.

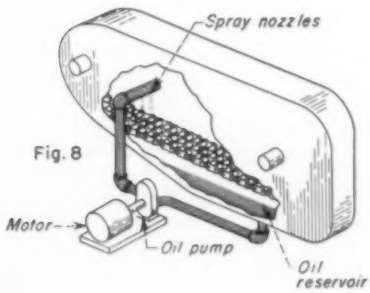


Fig. 8

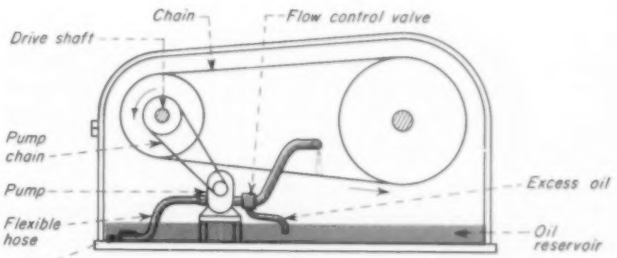
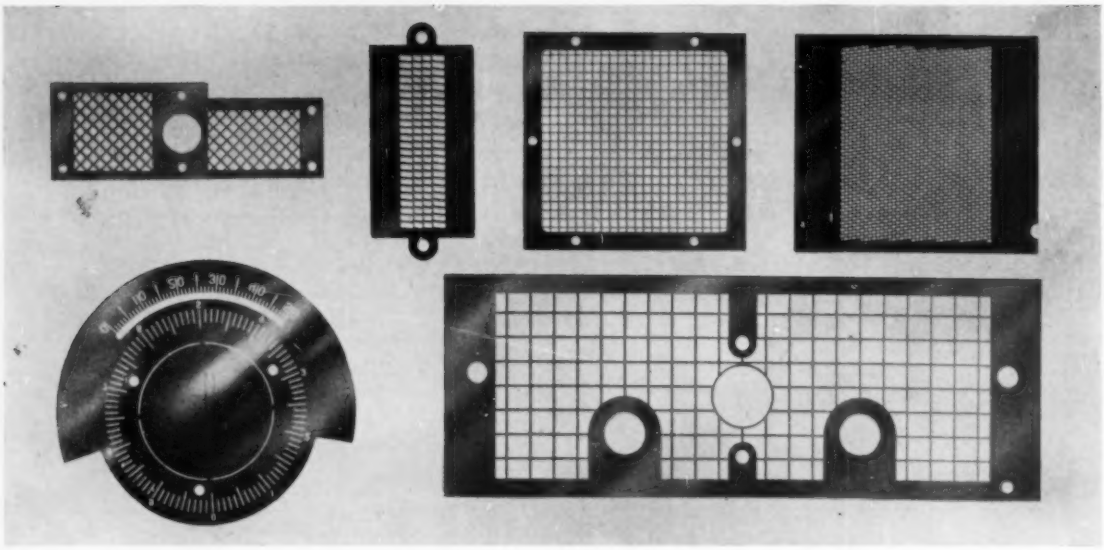


Fig. 9

FIG. 9—*Chain-driven force-feed* system has pump driven by main drive shaft. Flow control valve, regulated from outside of casing, by-passes excess oil back to reservoir. Inlet hose contains filter. Oil should be changed periodically—especially when hue is brown instead of black.



Acid Etching *and* Electroforming *Precision Parts*

MARVIN C. COOK
Product Development Engineer, Buckbee Mears Company

PRECISION SCREENS, optical reticles, cutaway dial faces, and flat contact fingers are the kinds of parts which may be economically made by these two processes. Tolerances are uniformly close, the metal is not distorted or cold worked and finished parts are free from burrs.

Both methods originate with a drawn or machine ruled master but an etched part starts with a sheet of thin metal in which selected areas are later removed by the action of an acid. An electroformed part is built up on a master with prepared conductive and nonconductive areas.

Neither process is one which will be carried out in the average shop or production department. However, the discussion below includes enough detail to make the reader familiar with the characteristics of the processes so that a designer may contract for their use with confidence.

ACID ETCHING

Starting point is a large scale drawing made on white paper or board. Holes or cutaway sections are left white, metal areas are filled in solid with black ink. Scale of this drawing depends on accuracy required in the finished part and the natural limitations of drafting accuracy.

The master drawing is then photographically reproduced on film or glass as a full size negative. This reproduction may require several photographic steps with frequent dimensional checks after each step. Accurate and careful camera work is essential for distortionless reproduction.

Ordinarily a part will be etched from both sides simultaneously. This means that two identical glass or film masters must be made with precise registry marks permitting accurate alignment. Metal stock is coated with a photo sensitive acid resist, sandwiched between the glass or film masters and exposed. The process of exposing coated metal stock to arc lights is very similar to the standard photoengraving process.

Unexposed areas (white areas on the original drawing) are reduced out in chemical baths. The metal is then subjected to a spray of ferric chloride or a similar etchant chosen for the material being etched, the etchant is

Table I—Metal Etching by Photo-Mechanical Process

APPLICATIONS:	Fire control reticles, optical reticles, scales, calibrated dials, fine ventilator filter and blower screens for electronic equipment, shaver cutters and combs, color television shadow masks, precision reed banks, mechanical parts too complex for die stamping
METALS:	Copper, brass, beryllium copper, phosphor bronze from 0.0005 to 0.020 in. thick. Nickel, cupro-nickel, Monel from 0.001 to 0.014 in. thick. Stainless steel, spring steel, cold rolled steel, aluminum up to 0.015 thick.
TOLERANCES:	Linear to 3 in. ± 0.0002 to 6 in. ± 0.0004 to 12 in. ± 0.001 to 24 in. ± 0.003 Angular ± 30 sec. Line Width to 0.002 ± 0.0001 to 0.005 ± 0.0005 to 0.010 ± 0.001 to 0.050 ± 0.002

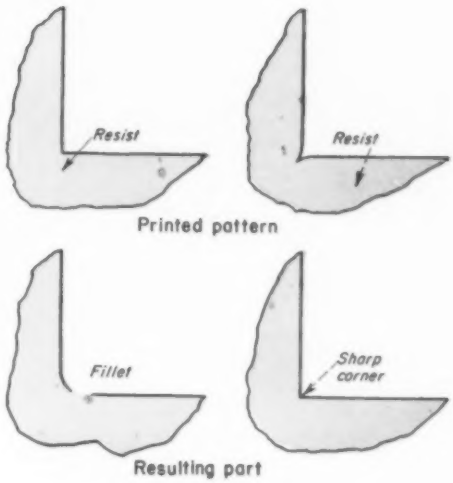


Fig. 1—Etched corners leave fillets rather than sharp changes of direction. To compensate a deep V is made in the resist pattern.

Description of methods, applications, production techniques and design considerations.

washed away after it has done its work and the part is ready for use.

Etching both sides of the stock simultaneously requires almost perfect registration of the two sides. Etching time is cut in half and the bevel at the cross section of an etched opening is more easily controlled. Tolerances of ±0.0002 and closer are achievable with this process. Table I lists some typical applications and dimensional accuracy possible.

GLASS ETCHING

Glass scales, reticles and fine rulings are produced by essentially the same process as metal parts. Since these seldom require etching through, printing on both sides is rarely necessary. Most glass parts are etched to a depth of 0.0003 to 0.005 in. and filled in with a permanent opaque filler.

Accuracy of etched glass patterns depends largely on glass quality and much closer control of the etching process is required. Stronger acids are used with silver or wax as resists. If the photographic method of applying the design is used, the additional photosensitive resist must be applied over the standard acid resist. This is usually a spray or bath of Rochelle silver salt which is then developed out in a separate chemical solution. A pattern may also be mechanically ruled directly on a hard wax coated glass surface and then etched.

Tolerances may be maintained to ±0.0001 in. on line width (Table II) which is more accurate than any method of mechanically cutting into the glass surface.

DESIGN

Most metals may be etched. However, steels high in carbon or alloy steels such as the 400 series stainless and chrome-moly require special techniques. Flat parts under 0.020 in. thick and made from alloys of copper, brass, and stainless steels are ideal for the etching process. These may be small, intricate scales, reed banks and parts having holes or slots whose diameter or width is not substantially smaller than the thickness of the base metal. For some

Table II—Glass Etching

PHOTO-MECHANICAL PROCESS	
APPLICATIONS:	Reticles for fire control and test fixtures either flat, convex or concave, halftone screens, calibrated dials.
GLASS TYPES:	Polished ordinary plate, water white plate, optical crown, borosilicate crown, baryta flint.
FILLING MEDIA:	Titanium dioxide, ferric oxide red, ferric oxide black, ferric oxide yellow, conductive metallic silver.
TOLERANCES:	Linear to 3 in. ± 0.0001 to 6 in. ± 0.0005 to 12 in. ± 0.002 to 24 in. ± 0.004
Angular ± 30 sec.	Line Width to 0.001 ± 0.0001 to 0.002 ± 0.0002 to 0.005 ± 0.0004 to 0.010 ± 0.0005 to 0.050 ± 0.001

MECHANICAL RULING	
APPLICATIONS:	Calibrated dials, reticles, scales, metallic film opaque reticles, prisms.
RULING TYPES:	Straight line, cross line, radial line, arcs and bands, concentric circles.
FILLING MEDIA:	Titanium dioxide, ferric oxide red, ferric oxide black, ferric oxide yellow, conductive metallic silver.
TOLERANCES:	Linear to 14 in. and concentric circles to 10 in. diameter ± 0.000039 not accumulative. Concentricity of pattern to outside diameter ± 0.0002 TIR Radial lines ± 6 sec. not accumulative. Line Width to 0.0003 ± 0.00005 to 0.001 ± 0.0001 to 0.010 ± 0.0003 over 0.010 ± 0.0005

metals holes as much as ¼ less than metal thickness are possible. Small decorative grids and screens are also being made economically.

Thickness is limited by etch time required to eat through the metal. Photosensitive resists will break down before unprotected areas are completely etched through thick sections. The silk screen process offers a partial solution to this problem since resists may be stronger, but a sacrifice must be made in edge definition and tolerance. Experimentation with fine, electroformed mesh as the screen shows great promise.

Precision depends largely on accuracy of full-size master. This involves considerably more than just producing an accurate drawing 10 to 100 times size and filling in the solid areas with black ink. Various allowances must be made depending upon the type of metal to be etched, metal thickness and the particular pattern or design.

Sharp corners on drawings and master are not etched into sharp cut outs. A fillet is formed because of the difficulty of fresh etching solution reaching into the corner. Fillet radii will depend on the metal being etched, strength of the etching bath, and etching time. Often considerable experimentation and experience are required before a desired corner section is obtained. V shaped grooves centered on the desired corner may help in achieving sharp corners as shown in Fig. 1.

Etching proceeds layer by layer on the exposed metal areas. Resulting cross sections, therefore, depend on length of exposure to the etching bath. Fig. 2 illustrates the successive stages of metal cross section for one side and two side etching. Two cautions must be observed in designing for etching as a result of this characteristic.

Change in metal material requires retest and experimentation to assure production of consistently acceptable sections and parts, since careful control of etching time is required to establish cross section shape and dimension. Certain metals, like the high carbon steels, require etching times that are so long that they threaten the resist itself.

Exposed areas should be balanced so that the entire part is completed at once. This refers to pattern layout in which holes or slots of varying width or diameter must be etched away. To achieve an optimum cross section at any particular place in the pattern an experimentally determined etching time is required. However, all places on a single part must be etched for the same length of time since one cannot limit an etching spray to a small area of a pattern. Fig. 3 illustrates how area balance might be achieved for a series of holes of increasing diameter. Note that the smallest hole determines the exposure time and all larger holes are blocked out with resist so that they are etched out in the previously determined etching time.

The same reasoning applies to thicker metals. By the time a thick section is etched through, areas immediately adjacent to resist will be eaten away and the resulting opening will be larger than the original clear areas on the master. Patterns are printed with exposed areas closed up somewhat to anticipate the expected undercutting which long etching times are bound to produce.

PRODUCTION PRACTICE

Etching equipment is in use in which every operation except the photoprinting is continuous. Width of the metal that can be handled is usually limited by widths available from rolling mills. An additional limitation is the size of the photo-printing frame although very large printers can be used if necessary. Smaller parts such as electric shaver combs, ventilation screens, flat spiral springs and reticles can be arranged on the original master so that as many as 400 to 500 parts are printed at one time in the vacuum frame. Such parts may be etched completely out of the strip or small holding tabs may be left for later cutting.

Intricate parts such as shaver heads may be etched in strips with accurate tool locating holes positioned opposite each part. The etched strips are processed through simple dies and the parts blanked out. Parts attached to a strip at a non critical point may be sheared out just before assembly. An example of this is the electrical contact fingers shown in Fig. 4.

Contacts are furnished in large sheets or rolls and

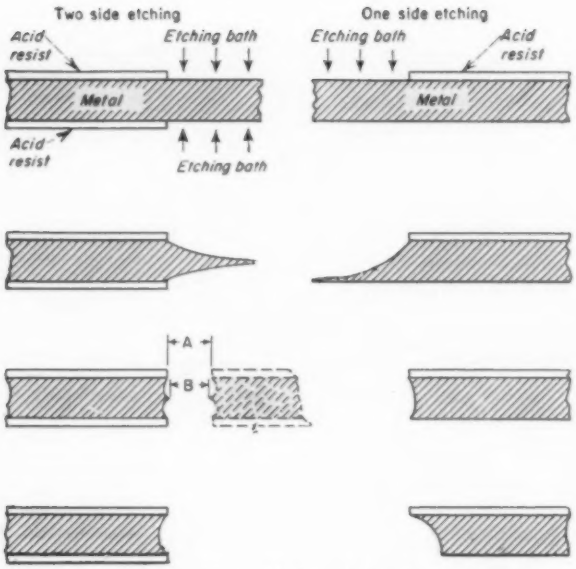


Fig. 2—Progress of etching acid through metal. *A* and *B* dimensions may be held to tolerances of 0.0002 to 0.0003 in metals 0.005 in. thick and under. The hourglass cross section may be very pronounced in thick metals which etch slowly and hardly noticeable even under magnification in metals which etch more readily such as copper alloys and certain steels.

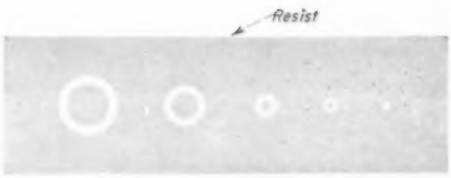


Fig. 3—Balanced areas exposed to etchant permit all sections to be completed in the same time.

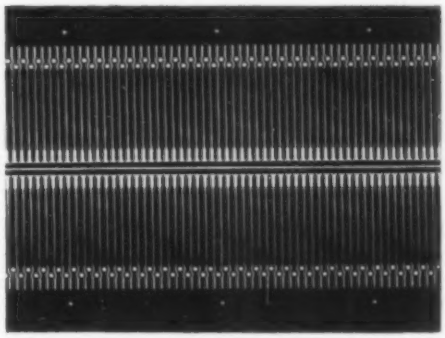


Fig. 4—Strip of contact fingers etched in a continuous copper roll. The desired number of fingers are sheared out prior to assembly.

etched out completely except for small connections at one or both ends. Attachment holes are maintained in their correct relative position and blocks of fingers are removed by shears and assembled as a group rather than individually.

Fabrication cost of etched parts is almost directly proportional to the area that can be coated, printed and etched in one series of operations. A spring, for example, that can be reproduced 400 times in one square foot of metal surface will be substantially cheaper than one that can be reproduced a fewer number of times in the same area. The cost of processing one square foot of a given metal is approximately constant if tolerances and general complexity of the part remain the unchanged. In both instances the master is produced by stripping in as many prints of the design as possible on the maximum area the etching machine and printer can handle.

To reduce etching costs, therefore, masters are made to include as many parts as possible within the available printing frame and associated etching equipment. Photocomposing boards are frequently used to quickly and accurately step and repeat a given pattern on the master.

Fig. 5—Inspection of light transmission through the color television aperture mask. Densitometer measurements are related to hole size and provide a quick inspection procedure.

APPLICATIONS

First real progress in precision etching of intricate parts was made during World War II when etched metal parts successfully replaced glass reticles. Fire control systems employing glass lenses and reticles were exposed to high temperatures and reticle images burned out. Copper reticles 0.002 to 0.008 in. thick were held to essentially the same tolerances as etched glass reticles. Lines corresponding to opaque areas in glass were left and stencil type numbers used. Metal reticles were indifferent to high temperature and cheaper.

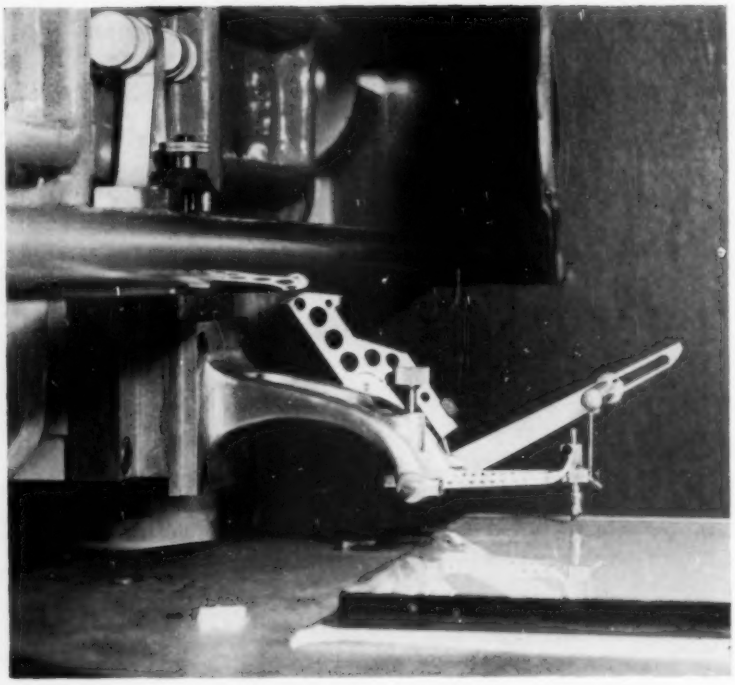


Fig. 6—Head of a large ruling engine. Diamond point and special support permit ruling of grooves as small as 0.0001 inches.

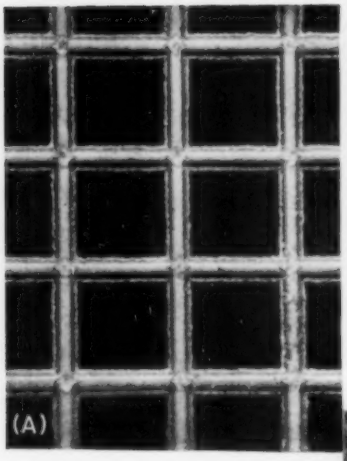


Fig. 7

Fig. 7—(A) Nickel mesh of 500 lines per inch magnified to show characteristic mushroom shaped cross section. (B) Glass master of 500 lines per inch. Lines are later filled in with opaque material and used to expose metallic and resist base for later electroforming.

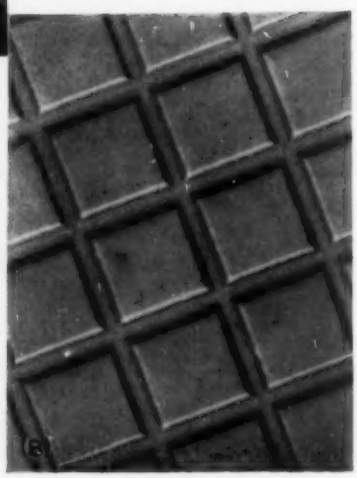


Fig. 8—(Far right) Progress of material build-up of electroformed mesh on exposed metal and resist.

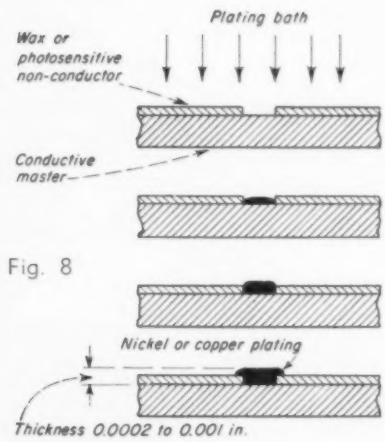


Fig. 8

More recently the same process has been applied to commercial products such as electric shaver heads, color television aperture masks, electrical contact fingers and numerous flat parts. The aperture mask is produced in quantity by a continuous process. Rolls to close tolerance metal 25 in. wide and up to 60 ft. long are handled. The metal is a copper-nickel alloy (96, 4 per cent), 0.0075 in. thick and rolled to a tolerance of ±0.0005 in. for the close etching control required. Masters with opaque dot patterns on glass are used to print both sides simultaneously in close register. Unexposed dots are developed out and the sheet is fed through a pressure spray.

The mask consists of 400,000 holes each 0.0095 ± 0.0005 in. diameter. Center to center spacing is also controlled to 0.0005 in. tolerance. Final inspection, as shown in Fig. 5, consists of a densitometer check of light transmission through several selected areas. Transmission figures can be correlated to hole tolerances.

Engine ruled masters similar to those used in producing fine mesh are also used to etch oil grooves or friction surfaces on cylinders. A precision ruled pattern is printed on film and the film used to transfer the pattern to the metal part to be etched. By this process uniformly fine lines can be obtained which are not achievable by knurling or other machining methods. Bars with 250 to 300 fine grooves per inch are used in computing and measuring devices.

ELECTROFORMING

Preparation of the master for this process may be identical to the method for etching. More frequently, however, the electroformed master is made at full scale with a ruling engine. This is particularly true if the part is a fine mesh of crossed straight lines. A large ruling engine capable of ruling up to 8000 lines per inch over an area 30 in. by 30 in. is shown in Fig. 6.

In the photographic process a photo-sensitive non-conductor is applied uniformly to the surface of a metal plate. The design is printed on one surface only and the unexposed areas reduced out. The metal plate now has a non-conducting design reproduced on its surface. It is placed in a plating bath and the conducting areas plated to the desired thickness. This plating is then stripped from the base metal.

A sheet of 500 mesh is shown in Fig. 7(A), and the master from which this was produced is shown in Fig. 7(B). Electroforming is therefore the reverse of the etching process. The desired part is built up in a plating process rather than by removal of selected areas by acid etching.

DESIGN

Many of the principles discussed in etching design apply equally well to electroforming. Once the basic process is understood, straightforward reasoning will warn the designer of the problems likely to occur.

An electroformed cross section is built up layer by layer in exactly the reverse of the etching process. Fig. 8 illustrates successive stages in the plating bath. Note the typically mushroom shaped cross section that results from a plating thickness which is ordinarily thicker than the insulating layer.

When fine meshes are produced by this method the hole or opening size is highly sensitive to the plating time. Holes begin to close up as soon as plating equal to the insulating thickness has been built up. Table III lists some typical electroformed mesh.

Table III—Typical Electroformed Mesh

Lines per in.	Mesh Size, in.	Highest Transmission, per cent open	Hole Width, in.	Wire Width, in.
1000	3 1/2 x 3 1/2	48	0.00069	0.00031
500	7 1/2 x 7 1/2	70	0.00155	0.00045
400	7 1/2 x 7 1/2	60	0.00193	0.00057
250	7 x 7	70	0.00335	0.00065
200	7 x 7	50	0.00353	0.00147
150	14 1/2 x 14 1/2	40	0.00422	0.00244
100	7 x 7	60	0.00773	0.00227

PRODUCTION PRACTICE

Electroforming is less amenable to continuous production than is acid etching. Time to plate is dependent on chemical, electrical as well as mechanical factors in the plating bath. The same master may produce grids or meshes of varying porosity depending on the length of time of immersion in the plating bath.

In order to economize and make best use of larger plating baths, photo composing equipment similar to that used in the graphic arts industry is used to repeat identical slot or hole patterns. This may be done accurately and it eliminates considerable drawing and composition of a single repeated pattern.

Equipment of this kind is also used to print, and accurately register, patterns which will be reproduced on both sides of metal or plastic board. For example double sided printed circuitry with plated through holes or connectors need accurate registry, particularly for miniature and transistor applications.

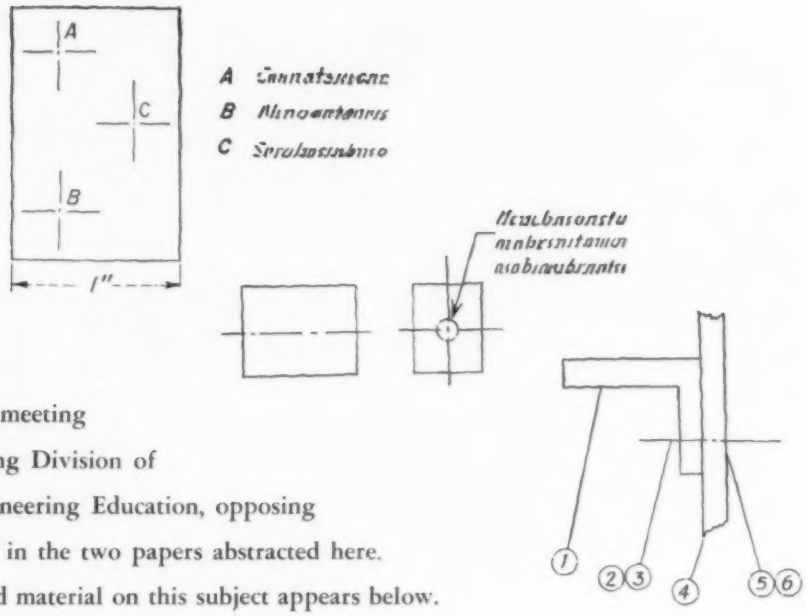
APPLICATIONS

Fine nickel and copper mesh are used primarily in electronic storage tubes. These tubes store numerals and other data for visual reproduction on a screen. The image may be retained at constant brightness unlike the cathode-ray-oscillograph in which the information cannot be stored. The storage target is electroformed mesh coated on one side with a dielectric and ranging from 250 to 1000 lines per in. Thickness of this mesh ranges between 0.0002 to 0.001 in. depending upon the percent open area and fineness required. Another application is image orthicon tubes for television cameras. For this use 500 line mesh permits a fine resolution. Large masters are not required for most electronic applications. Table IV lists additional applications and specifications.

Electroformed mesh is also finding increased application in particle sizing and as precision mechanical filters. The finest commercially available woven wire mesh is 400 lines per in. This material does not possess uniformity of hole size, varying as much as ±7 per cent. Electroformed mesh is produced with hole variations under one-half of one percent. This material can be electro-bonded to coarse supporting grids with large open areas for increased strength or it may be supported between two sheets of porous material.

Table IV—Electroforming by Photo-Mechanical Process

APPLICATIONS:	Grids for electric discharge devices, precision shim stock, precision gratings, image-orthicon mesh, storage tube mesh.
MESH TYPES:	Grid mesh from 10 to 200 lines per inch. Mesh with lines differing horizontally and vertically, e.g., 100 LPI x 200 LPI. Fine mesh from 50,000 to 1,000,000 holes per square inch.
METALS:	Nickel, copper, lead, laminations of nickel and copper.
DIMENSIONS:	Up to 100 LPI, 90 per cent maximum open area with thickness of 0.0002. Up to 500 LPI, 65 per cent maximum open area with thickness of 0.0001. Up to 1000 LPI, 50 per cent maximum open area with thickness of 0.0001. Up to 80 mesh, 70 per cent maximum open area with thickness of 0.0015.



At the annual mid-winter meeting of the Engineering Drawing Division of American Society for Engineering Education, opposing viewpoints were presented in the two papers abstracted here. A brief review of published material on this subject appears below.

Simplified Drafting—Pro and Con

DEAN J. GERARDI, University of Detroit, Detroit, Mich.

HOW IT STARTED

In 1953, Messrs. Healy and Rau of General Electric Company published a book under the title of "Simplified Drafting" which was widely distributed to American industry and teachers of engineering drawing. It is my opinion that the book is largely responsible for the present interest regarding drafting simplification.

In January, 1954, copies of the practices which had been approved by the Drafting Standards Committee of R.C.A. were distributed.

A few months later editors of engineering magazines, both here and in England, latched on to the idea of simplification and extolled the courage of pioneers who advocated new and extreme methods of drafting.

In May, 1954, I expressed my views on this subject in an article published in *Product Engineering* entitled "Should Drafting Practices be Further Simplified?" This was reprinted in *Machinist,* a British publication.

During the Fall of 1954, the American Machinery and Foundry published its version of simplification. This, too, was widely distributed to industry, vocational schools, and engineering colleges.

In the Spring of 1955, the McCormick Works, which is one of the operations of the Farm Implement Division of International Harvester, distributed a brochure entitled "Simplified Drafting Data Sheets." The data sheets were sometimes construed as representing the practice of the entire International Harvester Company, but investigation developed that the simplification was limited to the Advanced Engineering Department of the McCormick Works. Their products consist of hay loaders, hammer mills, side rakes, etc., most of which involve relatively simple components. In this connection, I have been informed that International Harvester, some years ago, investigated the advisability of simplifying its drawing systems but found that it required the services of special committee to which it could be applied, and an involved drawing for which it would be unsatisfactory and confusing.

The June, 1955 issue of *Product Engineering* contained an article by Professor Grant of Washington University which was entitled "Reducing Cost in the Drafting Room." The Professor mentioned nine specific areas which, if implemented, would result in cost reduction and drafting room efficiency. However, he did not support the idea that simplified practices on a broad basis contributed to economical operation.—J. Gerardi

DURING THE PAST TEN YEARS several thousand people have devoted an enormous amount of time and money towards standardization of American drafting practices. The term "simplified" as applied to standards of any kind has many interpretations in industry. Many organizations consider the reduction or simplification of variety of items as standardization. Others construe simplification as the reduction of essentials to the lowest common denominator. I favor the latter viewpoint, distinguishing standardization and simplification, but believing that effective standardization involves a certain amount of simplification.

Proponents of simplification have invariably claimed that

it has saved them thousands of dollars. We must appreciate that claims are one thing and proof is something else. Long experience with any practice is the most reliable guide to its effectiveness and ultimate economy. Many companies have undoubtedly converted to extreme simplification with immediate savings of drafting time, offset only by the time involved in training their personnel. The books on this matter, however, cannot be balanced immediately. Time will have to elapse, drafting personnel will have to change from time to time, new suppliers will have to come into the picture—all, incidentally, involving further education which costs money and may involve delay. It may be expected that on occasion, misunderstanding as to the intent may arise with rejection of shipments involving tens of thousands of dollars requiring adjudication as to who is responsible.

I may have given the impression that I am opposed to simplification. If simplification of drafting means the rendition and calling out of requirements in a manner which cannot possibly be misunderstood, a manner which could be upheld in any court of law and which is practically foolproof, I am for it regardless how many short cuts may be involved. On the other hand, if simplification is going to mean diagrammatic sketches which have to be explained to those who are not familiar with the system—a code as it were which requires a code book to decipher—then I am not for it and contend that like all codes, it sooner or later will become too involved for even its most enthusiastic proponents.

Simplification of drafting practices is desirable, but that means simplification based on sound standardization of practice. The Society of Automotive Engineers and the American Standards Association are working on drafting standards which ultimately will afford a uniform national practice. In those standards great strides have been taken toward reasonable simplification of rendition which clarifies rather than confuses the intent. In many instances, the standard practices afford optional methods of rendition, some of them more expensive than others, leaving to the judgment of the draftsman or his supervision which method should be adopted or which method meets the requirements.

Simplified Drafting Is a Supplement

JAY H. BERGEN, Standards Administrator, American Machine & Foundry Co., Greenwich, Conn.

ONE OF THE MOST FREQUENT ARGUMENTS heard against simplified drafting is that manufacturing will spend more time interpreting simplified drawings than will ever be saved in drafting and that over the long term, money will be lost and over-simplification defeat its own purpose. We at American Machine & Foundry agree wholeheartedly if confusion is caused in the shop by drawings of the simplified type.

In the fall of 1952 our Buffalo Engineering Department prepared detailed and assembly drawings on two similar pieces of equipment. Set "A" was prepared under what we would consider normal drafting room practices; set "B" was prepared using simplified drafting practices. Set "B" contained twenty per cent more detail and assembly drawings than "A," yet was prepared in 34 per cent less time.

These drawings were then released to our Buffalo Manufacturing Department and were used by them over a period of two years. In August of 1955 a general discussion on this subject was held with the personnel of this department in an effort to determine the validity of our simplified practices. The results of this discussion can be summarized as follows

1. Inspection Department: ". . . no rejects which can be attributed to misinterpretation of drawings of the simplified type."

2. Planning Department: ". . . no difficulties. On the contrary our people find far less need to go back to the engineering department for clarification of the drawings."

3. The Production Group states that,

A. Their training problem has been simplified on those jobs where the new type drawings are used.

B. There have been so many requests from production foremen for redrawing of the old drawings to the new standard that there is no question the new type drawing is far more preferable.

C. There was ready acceptance by the shop men.

D. There was less shop time consumed in reading and interpreting drawings and their specifications.

E. Assembly was facilitated through the use of the modified, more readable assembly drawings.

We have no argument with Dean Gerardi when he states that he promotes simplified practices which have been standardized by such authorized agencies as SAE, ASA and others. We feel that standards with reference to drafting room practice are very valuable and that they should be reviewed periodically with an eye toward simpler and more economical practices. We do not advocate that all companies adopt our or anybody else's suggestions for simplified drafting, but we do feel such suggestions should be brought to their attention so they can determine for themselves whether or not money can be saved. Our experience has proven to our satisfaction that we can effect appreciable economies.

We expect our detailers, designers, group leaders and group supervisors to use common sense in applying the rules of simplification. If, for example, a dimension is placed within the field of the drawing, we expect that common sense would indicate arrowheads should be used on the dimension lines. There are other cases where the lack of arrowheads would be confusing, and we expect that arrowheads would be used. The rules as set forth in the A.M.F. publication on this subject have been worded very carefully so that they are more suggestions

than commands. For example, we state, "Avoid the use of arrowheads," "Avoid the use of hand lettering," "Avoid the use of dotted lines that do not add clarification." We feel that industry does a great deal more harm than good in setting down ironclad rules on how drawings should be made. We pay our designers and detailers well and expect that their intelligence, education and experience will dictate the proper amount of simplification to be used in any specific case.

Many people in industry, including myself, feel that the schools must teach what we consider to be standard drafting practices before a student is taught simplified practices. Simplified drafting is a supplement and not a replacement for present day practices.

EDITOR'S NOTE:—As this abstract of Mr. Bergen's paper indicates, his position is based on extensive experience with a carefully developed procedure. The complete paper as presented before the American Society of Engineering Educators included the full text of two standards in current use by American Machine and Foundry. The first one covers conventional drafting practices as used for a number of years; the second describes the simplified practice referred to in his paper.

A thirty-six page booklet entitled, "Simplified Drafting," by Jay H. Bergen will be sent free, on letterhead request, to interested readers. Requests should be addressed to Jay H. Bergen, Standards Administrator, General Engineering Laboratories, American Machine & Foundry Co., Fawcett Building, Greenwich, Conn.

What Is Your Experience?

Have you had an opportunity to get a direct measure of production savings (or losses) from the use of simplified drafting practices? Would you like to share those experiences with other readers?

Tell us about the circumstances leading to the use of the simplified system, what the major areas of simplification were, what type of components were designed? Have you made any changes in your simplified system as a result of your experience? Include one or two typical examples of "before and after" drawings of parts not too large for ready reproduction.

Address your comment to Editor, *Product Engineering*, 330 West 42nd St., New York 36, N. Y. Published contributions will be paid for at regular author rates.

From Argentina

To the Editor:

The letter of Mr. O'Neill and your answer (November 1955 page 449) prompts me to write about that much debated subject of Simplified Drafting.

First, there are no over-all records on the savings of Simplified Drafting. By this I mean the savings in the drawing department compared with the alleged losses (in the opinion of the opponents of Simplified Drafting) in the shop due to more difficult interpretation.

Moreover, I do not remember having read the opinions of shop managers on this subject but only of people who say there may be difficulties in the shop. But they were not shop people themselves.

In my opinion you should conduct a survey on the subject among factories that apply Simplified Drafting. I have in mind your survey about users' complaints on machine tools ("What Users Want in Machine Tool Control," Sept. 1955). . . . in my opinion some definite opinions can come only from people who are in a position to evaluate the over-all effects of Simplified Drafting. Those above the heads of shop and drawing department. I have found that of the two foremen here one did not like Simplified Drafting on the grounds of appearance. But questioned if he had difficulty in interpretation he said there was none. —K. JANSKY

Tacuari 369, Tigre (PR.BS.AS), Argentina

EARLIER COMMENT—The article "Drafting Practices Should Be Standardized," by H. H. Ash, in August 1955 page 162, listed the articles and readers' comments published up to that time. Additional comments from readers that have appeared since then include:

"On Drafting Practice," by G. E. Rowbotham, August 1955, page 320, cautions against carrying simplification too far.

"Drafting Research," by M. O. Young, September 1955 page 316, suggests a time-saving procedure in preparing to draw.

"Simplified Concept Misunderstood," by W. H. Buchanan, October 1955 page 314, emphasizes need for education in use of simplified drawing.

"Drafting Procedures," by L. E. O'Neill, November 1955 page 449, in commenting on Mr. Ash's article, questions its effect on the user.

SPECIAL-PURPOSE MATERIALS

IN A CONTINUING EDITORIAL PROGRAM, during recent months the following articles have brought basic design data on a variety of special-purpose materials:

Constant Modulus Alloy for Elastic Elements, in this issue, page 135; mechanical properties and design stresses for a hardenable metal alloy.

Plastic Springs, June 1956 page 183; torsional elastic properties of resin with glass reinforcement.

Manganese Copper High-Damping Alloys, May 1956 page 135; properties and applications for alloys combining high strength and high damping capacity.

Plastic-Bound Magnets, April 1956 page 182; a material with Alnico V properties that can be molded like a plastic.

Fabricating Ultra-High-Strength Steel, December 1955 page 170; machining and heat treating specifications, physical properties and a check list for evaluating applicability.

Alloy Plating, September 1955, page 136; new combinations of properties; characteristics and applications for a copper-tin alloy with high deposition rate.

Metallized Plastic Films, August 1955 page 182; types of films and coatings, properties and uses for films coated by vacuum deposition.

Clad Metals, June 1955 page 162; fifteen types of composite materials; design functions and applications.

Heat Resistant Cast High Alloys, February 1955 page 163, includes data on strength and corrosion resistance under repeated heating cycles in atmospheres above 1200 F.

And many other articles in earlier issues, reporting new and significant developments in structural and elastic materials.

TECHNICAL NEWS

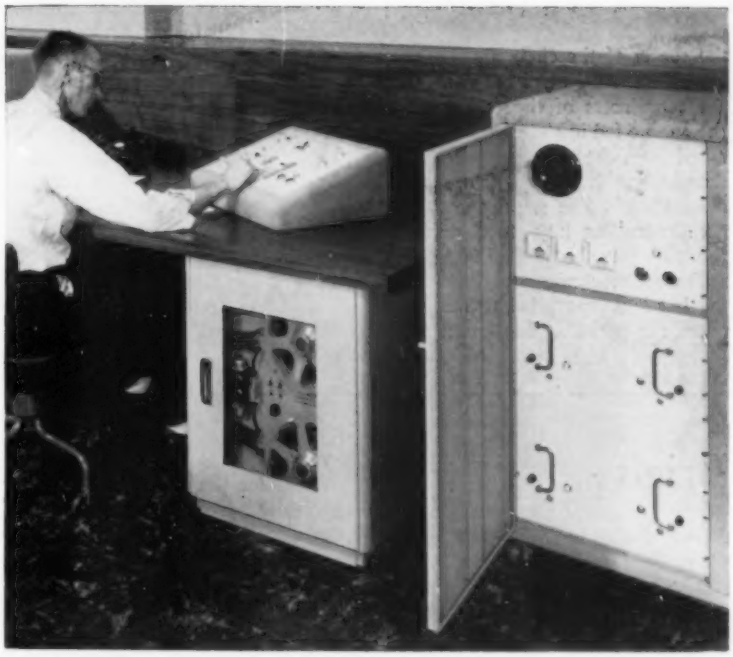
Automatic Miller Has Simplified Programming

Another phase of push-button machining was unveiled recently in the form of a numerical control device for operating complex machine tools by digital data that are automatically computed and recorded on magnetic tape. The device is called the "Digimatic," and was developed by the Electronic Control System, Inc., 2136 Westwood Blvd., Los Angeles 25, Calif.

The system consists of two principal units: a planning desk, the main part of which is a high-speed decimal computer and tape recorder, and a machine control unit which controls the operation of the machine tool from the data on the tape.

Before the machining operation, the dimensions of the finished part were fed into the planning desk through a keyboard similar to that of an adding machine. After each dimension was entered, the data was computed and the numerical data converted into pulse form on the magnetic tape.

A feature of the Digimatic is its ability to compute and record the proper instructions for milling true curves. For example: to mill a semi-circle 8 in. in dia into an aluminum plate, either the straight line travel or the circular travel was programmed on the existing equipment. A two-position switch can be turned to either straight or circular line. To get to the position where the operator starts the semi-circular cut, the mathematical data of the coordinates of the starting point are fed in. Next, the straight line travel of the milling head is programmed. This is the total of the distance of the cutter above the



DIMENSIONS OF A PART are entered into the planning desk. Computer (cabinet at left) interpolates information into pulse signals which are recorded on the magnetic tape (center, under desk). Cabinet at right contains power supply for all the units of the planning desk.

ALUMINUM WORKPIECE, just cut, has a large semi-circle, with the ends connected by two straight lines forming a 160 deg angle. A small circle was programmed and cut inside the semi-circle. Cost of the complete automating device of this vertical miller is about $50,000.

work and the depth of the desired cut. To this point he had programmed to straight lines.

Having established the starting point of the cut, the coordinates of the center of the circle are fed in to establish the radius of the cut. Then the coordinates of the end point of the cut are fed in. Then, the cutter is raised from the work by switching to straight line (vertical travel) and another straight line is programmed to get the milling head to the side of the work piece.

Present accuracies are within 0.001 in., but it is reported that finer tolerances are possible. Maximum travel of the work piece along the X and Y axes is 15 in. per min. In the vertical Z-axis, the max travel speed is 7½ in. per min. Electronic Control Systems says that it can furnish equipment to automate most existing milling machines, contouring lathes, profilers, cam millers, or boring mills.

Because of the machine's simplicity, any machinist who can read a blueprint could easily learn to program the operation of the device. Since the preparation of a recorded tape of instructions is required only when a new part is to be produced, one planning desk could serve five or more machine control units.

Briefs . . . .

Now operating at McDonnell Aircraft Corp., St. Louis, Mo., is a facility for full scale structural testing of missile components under heat conditions encountered at more than 5000 mph. A missile specimen 15 ft long and 3 ft in dia can be tested at temperatures up to 1000 F, and smaller structures at temperatures up to 1500 F. For example: a hypersonic missile flying at 90,000 ft at 5300 mph is subjected to a temperature of about 1500 F. The method of heating decided upon is a radiant heat system using quartz lamps and heat reflectors. This method allows wide flexibility.

High altitude television for jet aircraft reconnaissance has been announced by Philco Corp., Philadelphia, Pa., for the Air Force. The new airborne system will provide ground control points with pictures of troop movements or terrain, and it is possible to transmit a TV picture from near ground level as well as from the stratosphere, beyond antiaircraft fire. The system is compact enough to be carried in a single-seat aircraft. There is no problem in getting a clear picture from a plane traveling at supersonic speeds.

A vibrationless pneumatic hammer principle has been announced by the Armour Research Foundation of the Illinois Institute of Technology, Chicago 16, Ill. Basic concept is the recoil systems for high rate of fire weapons for the military. The solution to the problem was reached by putting a pneumatic spring between the handle and the main mass of the instrument. The main mass of the hammer absorbs the vibrations usually felt by the tool operation.

A self-locking cable grip which grips tighter the greater the load, will hold any type of wire rope or strand material, and will hold the full listed breaking strength of any wire rope. A test pull on a ⅝ in. wire rope will brake at 33,750 lb without the cable slipping. Called the Maxloc clamp, it grips the rope on both sides equally, and holds the wire rope in axial alignment. Easy to use, the rope is not bent or bolted in any way, and can be re-used many times. The grip automatically follows the diameter reduction of the cable as it stretches, and will not destroy the rope or cable by continued use. For further information write the designer, Maxwell West, Hotel McAlpin, Herald Square, New York, N. Y.

Present cost of material for an automotive 160 hp gas turbine engine runs about $97.20: After the machining processes, and the rest of the overhead, the price is up around $4.00 per horsepower, according to a Ford Motor Co. spokesman. While this is too high for mass use, there are reasons to believe that the cost can be brought down to the level of the recriprocating engine, which is about $1.00 per horsepower. Research also indicates at this point that the gas turbine will not require a synthetic lubricating oil, and that it will use a regular crude, about one quart every 10,000 miles. Progress also has been made in the use of aluminum-iron for gas turbine parts, and that aluminum iron wire is being drawn. This wire can be made to be quite ductile.

According to a recent issue of Magnesium, a magazine published by Brooks & Perkins, magnesium parts manufacturers, Mr. Perkins is angry at the Dept. of Defense for its scarcity rating of metals. A scarcity number is assigned to each number, with the exception of titanium, and this list is used to guide designers in specifying metals. The lower the number, the less scarce the material. Aluminum is 1; copper, 0.83; and steel, 0.025. The rub is that magnesium is listed as 10.9—very scarce. In addition to stating that magnesium production at present exceeds consumption by 30-million pounds annually, Mr. Perkins stated that the U.S. is not dependent on foreign supplies for its magnesium.

Science Teacher Shortage—The Air Force Has a Solution

General Nathan F. Twining, Air Force Chief of Staff said that something should be done about the shortage of science teachers, particularly on the secondary school level. The inadequate number of technically trained people could take on the nature of a true national emergency, if it has not become one already.

Twining said that, "Within the Air Force there are thousands of technically trained men in such fields as mathematics, general science, or geometry. These men are stationed all over the country, perhaps in areas where schools are either short of science teachers, or have none at all. Naturally this would be a voluntary program for both the school and our men, but we think it is one way to end a critical shortage. Just as the Air Force has stepped in temporarily to aid in other emergencies, we are now offering our help in this one."

Small Business Doing Well

Based on the Federal Trade Commission–Securities and Exchange Commission Quarterly Report for Manufacturing Corporations, small businesses in the United States are doing quite well, according to a recent report from the Chamber of Commerce.

The report shows that in the last year, corporations with assets of less than $250,000 have shown the greatest increase in profit margins of all classes. Profit margins for this group were 57.1 per cent higher than 1954 levels. This compares with an average increase for manufacturing corporations of all sizes of 20 per cent. Also, profits per dollar of sales for corporations from $250,000 to $1,000,000 in assets have risen faster than the average for all corporations, though not as fast as the profits of the smallest group.

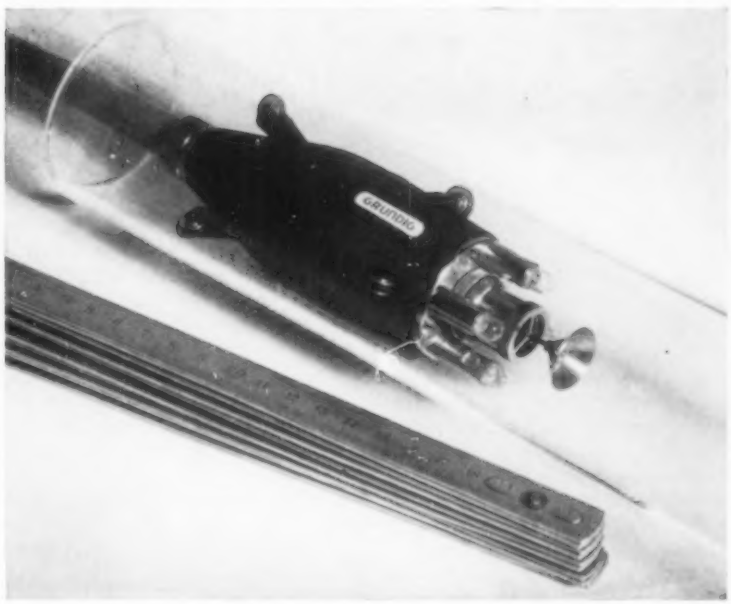
The Chamber of Commerce also states that while business failures have risen since 1950, the number of new incorporations in the same period shows a greater increase–36 per cent against 24 per cent. The Chamber asks, "If the pessimistic reports about small business were true, how could so many new businesses spring up?

Railroad Cars Become Wind Tunnel

Railroad oil tank cars, originally scheduled to go to Russia under the World War II lend-lease program have been joined together at the University of Michigan, and the resulting unit is a wind tunnel for experimental work. After the under structure has been removed, nine cars, one behind the other form a vacuum tank of 13,000 cu ft.

After the test operation has been set up in a wind tunnel, air is pumped from the tanks. At the same time dry air is stored in a larger storage tank. When the vacuum has been pulled, air is released from the storage tank to the vacuum tanks giving air velocities in the 750 to 3000 mph range.

Another project will be to release pressurized air into the converted tank cars to get wind velocities of 5 to 10 times the speed of sound.



Miniature TV Camera Inspects Boiler Tubes

Perhaps the smallest television camera in the world, this miniature unit has a diameter of only 47 mm and a length of 150 mm. Its specific use is looking for flaws on the interior walls of boiler tubes. The camera is equipped with special lenses and a rotating mirror, and has a lamp for illuminating the interior tube walls.

Tubes or smoke flues as small as 60 mm in dia may be inspected. Springs on the rollers (see above) keep the camera in the center of the tube at all times.

A perlon thread is used to draw the camera through the tube. At the television screen, the image is enlarged twenty times. The manufacturer is the Grundig Radio Werke, Fuerth/Bavaria, Germany.

Vacuum Degassing Reclaims Scrap Titanium

Titanium that had been scrapped because of hydrogen embrittlement–$2½-million worth–has been successfully reclaimed by degassing with vacuum heat treatment by Kinetics Corp., an affiliate of High Vacuum Engineering Corp., Hingham, Mass. Coming from manufacturers of jet engines and airframes, the parts included finished and semi-finished compressor rings, blades, tubing, sheet, and wire. The restored metal had improved properties, with ductility and purity, better than that of the original material.

It has been learned that with the proper processing, the hydrogen content can be reduced from 200-400 ppm to 70 ppm, with the notch test values jumping from 60,000-90,000 psi before the degassing to 160,000-200,000 psi afterwards. The degassing cycles vary from several hours to 36 hr, at temperatures ranging from 1250 to 1800 F. Vacuum, required is 1 micron or less. The vertical, electrically heated furnaces have an 80 kva capacity. The Inconel nickel-chromium alloy retort is ¼ in. thick, and is 27 in. OD and 37 in. long.

For degassing, a 250 lb load of titanium is heated for 10 hr at 1250 F. The work is held at this temperature for 36 hr or more.

Stress relieving of titanium that has previously been vacuum treated either in the melting or solid stage is possible by treating at temperatures ranging between 1100 to 1350 F for a period of 8-9 hr.

Seen and Heard at the Design Engineering Show

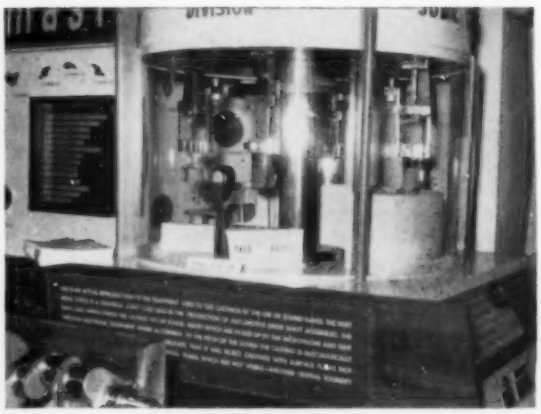
Those visiting the exhibits spent much time there—those attending the conferences found them interesting—the exhibitors were very happy ($$$)—the Design Div., of ASME, was surprised and pleased at the large conference turnout—and the staff members of **Product Engineering** are looking forward to an equally successful, but larger show next year.

Over 13,000 people visited Convention Hall to see the many products displayed by 180 exhibitors. And the Design Div., of ASME, says that the total registration for the conference exceeded 1250. Total attendance at any one session was never under 500, and one session had an estimated 1000.

As for next year, plans already have been made, and the Second Design Engineering Show will be held in the New York Colliseum from May 20-23. The conferences, which again will be handled by the Design Div., of ASME, will be held in one of the local hotels, since the Colliseum has no room large enough to accommodate groups of the size that attended the recent conferences.

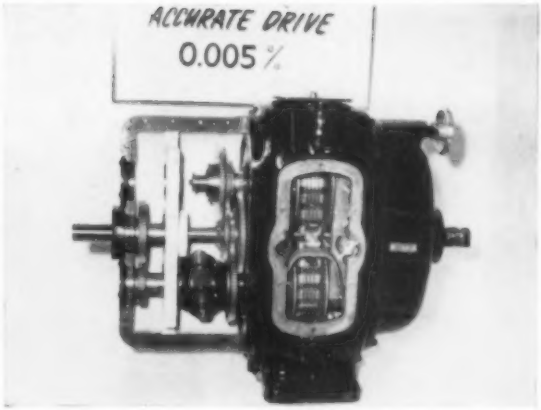
Some of the comments of exhibitors follow:—"We have exhibited at numerous shows, and have found that the attendance and response at this show far exceeds that of any other in which we have participated," PIC Design Corp.—"First day's inquiries exceeded that of any other show at which we exhibited. Best caliber of men ever assembled at a show," Dynamic Gear Co., Inc.—"We can't get over the quality of the attendance. Many people we've never been able to see came into the booth to learn more about our product," Franklin Dales Co.—"Five times better than any show we've ever been in. We've been looking for a show like this for years. Never have we had the opportunity to speak to so many high level design people in such a short period of time. We are looking forward to next year's show," Reliance Div., Eaton Mfg. Co.—"A very heavy concentration of just the people we must reach," Tinnerman Products, Inc.—"This is definitely our show," Merkle Korff Gear Co.—"This show was our first opportunity to contact the engineer face-to-face. If you have a product he can use, he storms your booth for facts," International Packings Corp.—"One of the best shows we've been in," Weatherhead Co.

◀ **FORMING REINFORCED PLASTIC PARTS** is no longer done by the "lay-up" method, whereby the reinforcing material is laid in the die and resin poured over it. The dish-shaped object being displayed at left was formed from a piece of duPont's reinforced plastic sheet like that held directly beside it. The ¼ in. sheet is lucite reinforced with Orlon acrylic fiber batting which stretches as the plastic part is being formed. At present, in duPont's test stage, parts 10 in. across and 5 in. deep have been vacuum formed. The sheet has: a tensile strength of from 6-8000 psi; a flexural modulus of 500,000-600,000 psi, compared to 400,000 psi for straight lucite, and 100,000 psi for polyethylene and tested to 2½ ft-lb in the impect test, as opposed to ½ ft-lb for lucite. When the sheet is vacuum formed, a preheating of 320 F for 5 min is necessary. DuPont predicts faster and easier production of parts with this method.



▶ **REPRODUCTION OF EQUIPMENT**, developed by the Central Foundry Div., of General Motors, which uses sound waves to inspect castings. The method is completely automatic and can be applied to production lines. Here a universal joint yoke is being tested. The machine has four work stations 90 deg apart. From the loading station the part is taken to the ringing station where a steel ball on the end of a rod is pneumatically actuated and strikes the casting. The resulting vibration is picked up by a dynamic-type microphone having special focal properties. The vibration is then sent through a pre-amplifier, a limiting amplifier, and into two discriminators which channel the frequency into the proper range. If the vibration frequency is in the "good casting" range, a latch relay permits it to be passed on to be spray painted, and dropped into the appropriate hopper. If not, the casting is dropped into the reject hopper.

THE M.D. (MECHANICAL DIFFERENTIAL) variable speed transmission with an unlimited speed ratio, maximum to zero, was shown by the Speed Control Div., of the Fairchild Engine and Airplane Corp., St. Augustine, Florida. Using a Link-Belt P.I.V. transmission, variable in speed from ½ to twice its input speed, one input to a bevel gear differential is driven at constant speed, with the second member of the differential being connected to the variable speed output shaft. The third member of the differential becomes the new variable speed output which will operate at any speed between maximum and zero depending upon the setting of the P.I.V. Capacities range from 1 to 20 hp, and units are 90 per cent efficient.



A POORLY AIMED CAMERA lopped off the top of this exhibitor's head, but still showed his product—a section of honeycomb extruded Buna-N rubber. Made by the Multiple Extrusions, Inc., Winona, Minn., the technique was developed initially for resilient cores in journal box lubricators. However, it can be used on any extrudable metal and plastic. In addition, the process is automatic and continuous, and in almost any size and shape. Interest at the booth ran better than 5 to 1 in favor of aluminum multiple extrusions, with the end use for the most part being for heat exchangers or structural purposes. For rubber, a considered use is cushion and mattresses and for plastics translucent ceilings.

PRODUCTS USING THE Nickeloid prefinished metal are displayed at the booth of the American Nickeloid Co., Peru, Ill. The metals are available in the basic materials of steel, zinc, copper, brass and aluminum. On these five is a surface treatment of nickel or chrome. Steel and zinc also are available with a brass, copper, gold bond, or a tint metal surface. Available in sheets, strips, or coils, all of the metals are prefinished on either one or both sides. The metals have a strippable protective coating which permits it to be drawn, bent, blanked and formed without damage to the finish. The chrome coated steel sheet has a max gage of 0.062 in. and is good for intermittent service up to 1000 F.

A packed house of about 700 people were on hand to hear the panel discussion on "How to Get and Train Design Engineers." Speakers were: Chester Linsky, Asst. Prof., Dept. of Industrial Engrg. of Pennsylvania State University, A. A. Johnson, Mgr. of Engrg., Switchgear Div. of Westinghouse Electric Corp., and Bernard. Covner, Asst. Vice-Pres., Dunlap and Associates, Stamford, Conn. An interesting discussion followed from members of the audience. Additional comments by Professor Linsky on How Not to Recruit Engineering Graduates are set forth in an exclusive interview in this issue's Perspective's.

Change-Making Machine Handles Paper Currency

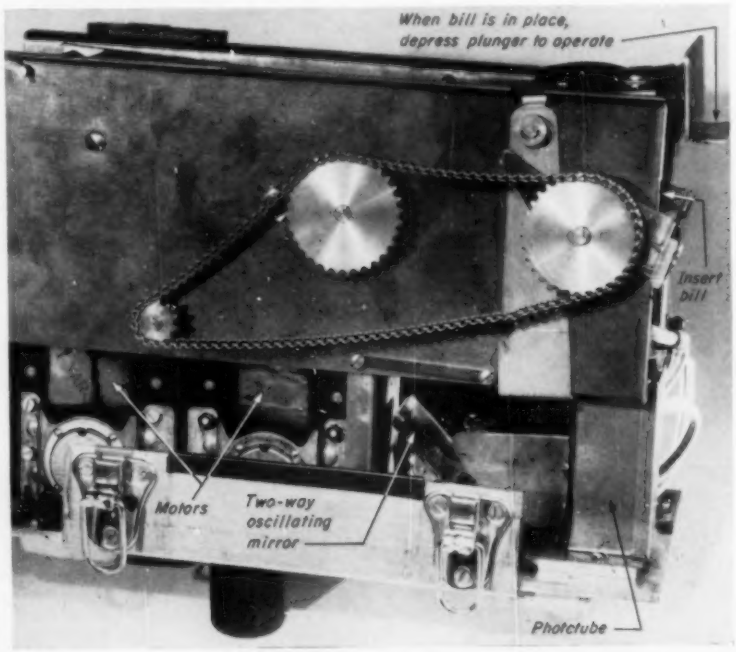
Present-day automatic vending machines are limited to products costing about fifty cents. If the price is greater, it requires the feeding of numerous quarters or other coins to make up the total amount. The solution to this problem is a vending machine that will accept paper money, and the Nomoscope shown here does just that.

Designed by the Nomoscope Co., 1475 Broadway, New York 18, N. Y., the operation of the device is based on a double oscillatory motion impressed upon an image of the paper currency to be examined. This image, which is a real optical image produced by a lens, falls onto a geometric pattern. The characteristics of the resulting light fluctuations can be brought out and distinguished when the light output is put through the necessary circuitry. No negatives, photographs, or reproductions are used.

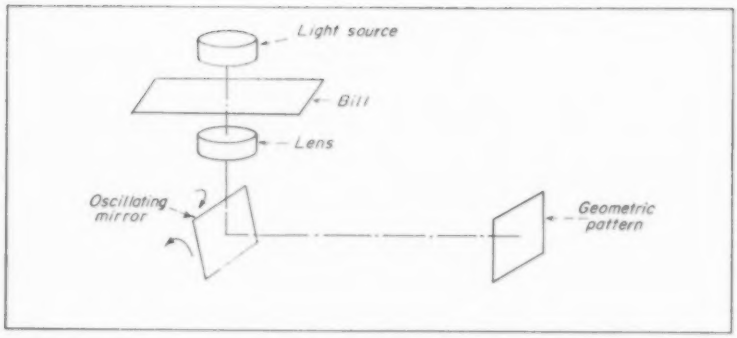
The image picked up from the paper varies with the denomination of the bill; therefore, as this machine operates only with one dollar bills, fives, tens, etc. are rejected. Likewise, counterfeit bills are also rejected.

The circuit performs the discriminating functions. A phototube receives the light output, whose supply voltage is controlled by a regulator circuit which compensates for line voltage and background illumination changes. The phototube output is

COMPLETE AUTOMATIC CHANGE-MAKING DEVICE is a small, portable unit. Dollar bill is inserted into slot at left, center, and change in coins is returned through slot at lower right. Directions for inserting the bill are on top of unit.



VIEW SHOWS ELEMENTS of change-making machine. Under the mirror is the two-way oscillating cam. The bill, green side up, is inserted all the way in the slot. After the operating plunger is depressed, the chain drive draws bill into container inside, and change is refunded in the slot on the opposite side (see above). Entire circuitry arrangement, using printed circuit, is on opposite side.



IN THE OPTICAL ARRANGEMENT, a lens produces an enlarged image of a part of the illuminated dollar bill. A mirror placed in the optical path deflects the light by 90 deg, and gives the required motions to the image. The mirror is rocked in two directions, at different rates, by a cam arrangement.

amplified in two separate channels. The output of one channel is rectified with a time constant, so that the rectified output is related to an average value. The other channel has a filter which is receptive to definite frequencies.

The filtered output is impressed on a final stage, which is biased negatively by the rectified output. Unless definite frequency components occur over definite percentages of the duration of the operating cycle, the final stage yields no output. The output signal is applied to a thyratron tube which operates a relay. The circuit is physically simple and only three tubes are used in the circuit.

Fluid Power Association Broadens Its Activities

As reported at the annual meeting of the organization, the year 1955-56 was one of great progress for the National Fluid Power Association. This relatively young organization of 65 member companies engaged in the manufacture of hydraulic components took on several new responsibilities during the past year.

As already reported in the ASA News, the National Fluid Power Association was admitted to membership in the American Standards Association as of Jan. 1, 1956. This enables the Fluid Power Association to have a voice in the establishment of all ASA Standards relating to hydraulic or pneumatic components and fluids.

To design engineers, the most significant and important report presented at annual meeting of the Association at White Sulphur Springs, May 28-30, was that of the Technical Board. It was presented by W. J. Kudlaty, chairman of the Technical Board, and assistant chief engineer of Miller Fluid Power Division. O. J. Maha of Hannifin Corporation covered the portion of the report dealing with the standardization of cylinder dimensions.

The full report of the Technical Board covered Terminology, Symbols, Fluids, Coding, Rating and Dimensions. Briefly, when completed the Terminology Report will include a glossary of terms. The Symbols Report is being developed in cooperation with committee Y32 of ASA and copies of a proposed draft will soon be issued to the membership. The report on Fluids, being developed under the chairmanship of F. A. Langenfeld of Monsanto Chemical Co., will include definitions, data and bibliography and is expected to be ready in a few months.

Comparable progress was reported on the sections relating to Coding, Rating and Standardization of Dimensions. The Ratings Committee under Allen W. Churchill, chief engineer of Automatic Switch Co., is working closely with the corresponding SAE Ratings Committee and also would welcome data on methods of rating hydraulic and pneumatic components.

Officers of the National Fluid Power Association for the year 1956-1957, elected at the Annual Meeting, are: for president, J. J. Pippenger, vice-president of Double A Products Co.; for first vice-president, R. J. Murphy, sales manager of the Kalamazoo Div. of the New York Air Brake Co.; for second vice-president, J. A. Marsh, vice-president of Rivett Lathe & Grinder, Inc.; and for Treasurer, Ellwood G. Peterson, president of Hannifin Corporation.

FTC Backs Up Water Conditioner Manufacturer

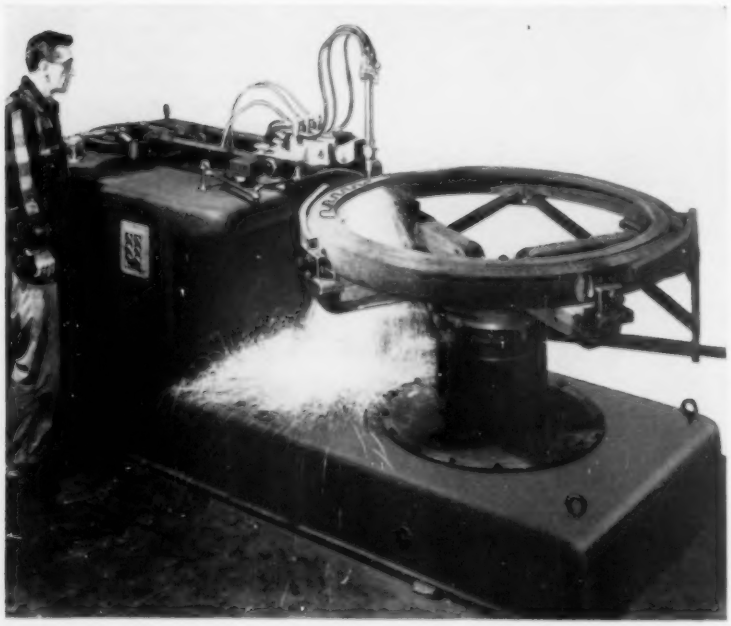
A Federal Trade Commission Hearing Examiner issued an order dismissing for lack of proof, the charges that the Evis Mfg. Co., of San Francisco, Calif., misrepresented the operation and advantages of its water conditioner. The complaint had charged to be false the company's claim that the conditioner has special properties, will beneficially treat water, make dishwashing more economical, and eliminate some of the destructive effects of water on pipes. The company says the device is made of a special metal that has a catalytic effect on the water passing through it.

The examiner said that "the device appears to operate on a principle unknown to or unrecognized by present-day science. The scientists admit that they do not understand the theory of its operation, and will not preclude that it may operate as represented." Ninety-two company witnesses, testified that their critical water problems were alleviated by this device.

The decision is similar in substance to that rendered to the well-publicized battery additive ADX-2, the manufacturer of which was also charged with misrepresenting the facts in claiming what the additive would do. Numerous scientists, in government and out, testified that if the additive worked, it was on a theory unknown to them. This case, which caused the expulsion for a time of the director of the Bureau of Standards, lasted 8 years.

THE NEWS IN PICTURES

THE ENGINE IS IN THE NOSE OF THE FUSELAGE of the new CH-1A Helicopter built by the Cessna Aircraft Co., Wichita, Kansas. A four-place craft with an engine delivering 260 hp to the transmission, it has a cruising speed of 100-120 mph with a useful load of 1000 pounds. Rate of climb with max gross weight (3000 lb) is 1000 ft/minute. The engine has been mounted horizontally in the nose to simplify installation and servicing, and to eliminate the special lubrication and induction systems required on vertically mounted engines, according to Cessna. Nose section is of formed fiberglass, and the removable wrap-around engine cowling is of aluminum. Rear seats are removable for cargo.

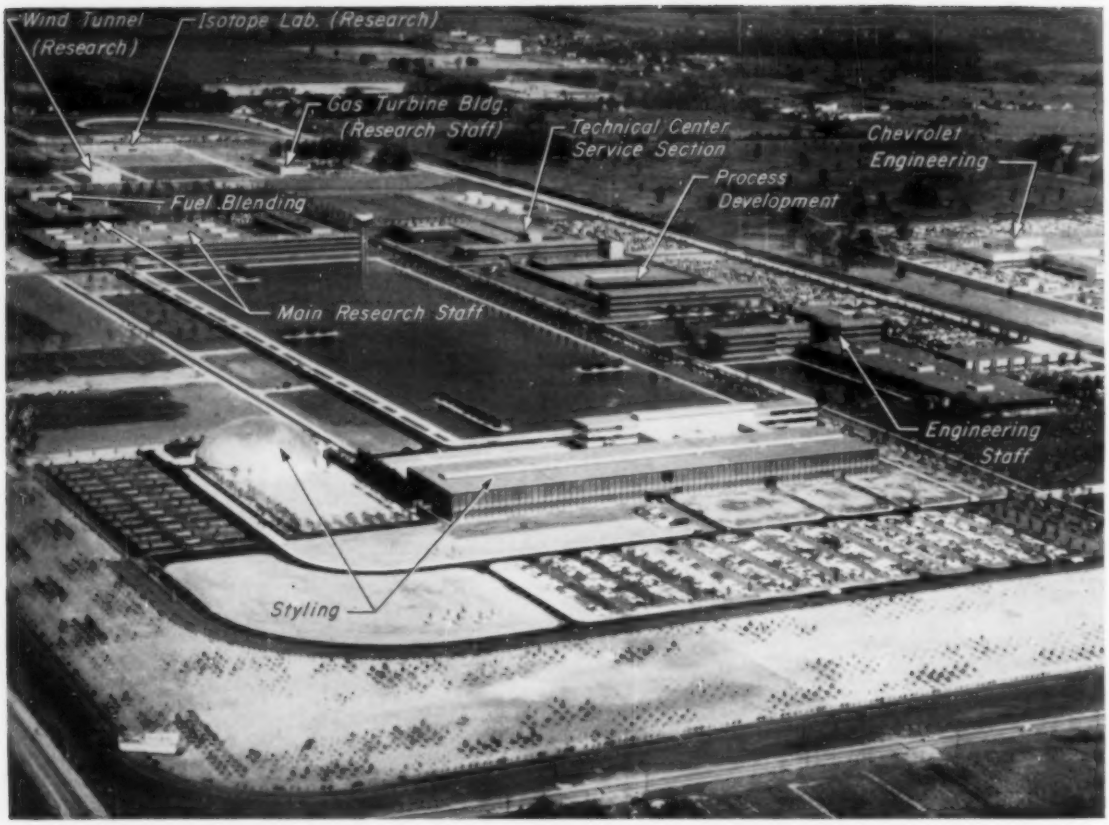


FLAME MACHINING TEETH in large sprockets and gears is speeded up by this new automatic process developed by the Seaman-Andwall Corp., 305 North 25th St., Milwaukee 1, Wisconsin. The process consists of a fast-cutting torch moving on machined ways, guided by a special cam for control of tooth shapes, sizes and spacings through a pantagraph mechanism. Tolerances are ± 0.007 in. on smaller sprockets to ± 0.015 in. on larger sprockets. Parts with diameters up to 100 in. and thicknesses up to 3 in. can be handled. Particularly adaptable to large gears and sprockets, Seaman-Andwall claim that cost savings increase in almost direct proportion to the size of the part. The part shown was produced in one operation in 30 min by flame machining, eliminating boring and machining, compared to 1 hr and 7 min of machining time after boring the inside of the ring.

QUICK CHECK OF A suspension system at the General Motors Proving Ground is possible with this television camera mounted on the bumper. The picture is transmitted to a 14 in. monitoring screen in the rear seat, or to a screen in the laboratory. The mobile system was developed in conjunction with General Precision Lab., Pleasantville, N. Y. Besides testing suspension systems, the device has been used for observing tire roll when going around a corner. Mounted under the hood, it sees engine rock, fan blade bending, or action of throttle and choke controls. The television camera can be used with a strobe light.

OPERATING ON standard 115 v current, this pint-sized electro-hydraulic shaker can apply a force of 55 G's to parts weighing 1000 pounds. The device was developed at Northrop Aircraft, Inc., Hawthorne, Calif., principally to test airframe sections holding electronic equipment used in the Snark intercontinental guided missile. One advantage of the unit is that unlike a magnetic shaker, the hydraulic system has no effect upon sensitive electronic components. Also, it can operate in either a vertical or horizontal position. The prime mover of the shaker is a vibration exciter composed of the hydraulic system and a special 2-stage electro-hydraulic servo valve designed by Bertea Products Co., Pasadena, Calif. Impulses transmitted to the valve's pilot spool are sent to the main spool which controls the movements of the piston rod shaking the specimen. Hydraulic pressure is built up to 3000 psi before the unit is put into operation. The frequency rang is from 5 to 600 cps with a ¼ in. stroke.

ORIGINALLY DEVELOPED to control the starting, stopping and interlocking of motion, time, sequence and recycling of press auxiliary equipment, this nine-point mechanical rotary limit switch is said to be so simple in operation that it can be used to automate a variety of machine operations. The switch can operate at various speeds, but is said to be particularly useful for the control of rapid operations. Each of the nine control stations on the face can be independently set through the complete range of 0 to 360 degrees. The individual switches are thrown on and off by a single rotating helical cam. Each switch is independent of the others, but if necessary, they could be set to make or break at the same time. Each station can be pre-set to within 1 deg, and the final micro-adjustment reduces this error to less than ¼ deg of arc. "Ganging" several 9-station switches on a single drive will offer any number of separate, controlled operating steps. A 4-station switch for simple applications is also available from E. W. Bliss Co., Canton 10, Ohio.



$100,000,000 Worth of Research Center

A bird's-eye view of General Motors Corporation's new Technical Center just outside Detroit. Occupying 330 acres, the Tech Center has 25 buildings ranging from gatehouses to large laboratories, office and shop buildings. The 4000 people working there consist of engineers, researchers, stylists, designers, mechanics, and machinists.

Actually, the central staff operations at the Center are organized along four general lines: (1) Research, directed by Dr. Lawrence R. Hafstad; (2) Engineering Staff, under Charles A. Chayne; (3) Styling, under Harley J. Earl; and (4) Process Developing, directed by John J. Cronin.

Research has 11 departments: engineering mechanics; metallurgical engineering; automotive engines and garage; mechanical development; special problems; gas turbines; fuels and lubricants; electro-chemistry; chemistry; physics and instrumentation; and industrial hygiene. Research is the largest of the four major staff groups.

Engineering Staff works on forward engineering policies and coordinates the product programs of divisions. Engineering Staff also carries out engineering studies and development of new products which are beyond the basic research stage. In addition to all this new product development, this group supplies engineering services and facilities to any GM division. The development phase is conducted by four specialized groups—power; transmission; vehicles; and structures and suspension.

Styling provides drawings that are the basis for engineering. Tht Staff's activities cover not only automotive and truck design, but household appliances, earth movers, railway trains, locomotives, and other non-automotive products. Styling's timetable is about two years ahead of a current model, 18 months ahead of the assembly line, 12 months ahead of production engineers, and 6 months ahead of Styling's fabricating shops.

The Process Development section is the newest group, and covers a field not touched by any other staff unit—the manufacturing zone which requires special engineering and research techniques of its own. Like Engineering Staff and Research, its facilities are available to all GM divisions. The section studies developments in electronics, metallurgy, chemistry, physics to see how they can be applied to manufacturing methods. The group conducts tests on products of interest to all divisions.

The Chevrolet Engineering building (upper right) is not considered part of the Tech Center. Not shown there are Fisher Body Central Engineering and General Administration, and GM's Photographic group.

COMING EVENTS

AUGUST 21-24

Western Electronic Show and Convention (Wescon), Pan Pacific Auditorium, Los Angeles, Calif. Sponsored by the West Coast Electronic Mfrs. Association, and the Los Angeles and San Francisco Sections of IRE. Over 700 exhibitors will be in the auditorium and other tent facilities. The number of technical sessions has been increased over last year. To be held prior to the opening day of Wescon will be a meeting of the National Telemetering Conference scheduled for the 20th and 21st. Technical sessions will be held covering new developments in that field.

AUGUST 27-29

Association for Computing Machinery, University of California, Westwood Campus, Los Angeles, Calif. For information write: G. W. King, Box 3251, Olympic Station, Beverly Hills, Calif.

SEPTEMBER 10-12

Fall Meeting, ASME, Cosmopolitan Hotel, Denver, Colo.

SEPTEMBER 10-15

Investment Casting Institute, University of Michigan, Ann Arbor, Mich. A six-day course in investment casting will provide members of the Institute with the latest technical data. Much of the information was developed through ICI technical committees. Because of the laboratory experiments which are to be part of the course, registrations are limited to 40 persons from the Institute's member companies.

SEPTEMBER 17-21

11th Annual Instrument-Automation Conference and Exhibit, New York Coliseum, New York City. Clinics, workshops and technical sessions will be conducted throughout the week program. Information on exhibit space can be obtained from Fred J. Tabery, Exhibit Mgr., 250 West 57th St., New York, N. Y., and on the educational program from the Instrument Society's national office, 1319 Allegheny Ave., Pittsburgh, Pa.

SEPTEMBER 24-28

1956 Trade Fair of the Atomic Industry, Navy Pier, Chicago, Ill. Sponsor of the Fair is the Atomic Industrial Forum, and the Fair is being held in conjunction with the Forum's annual conference on "management and technology for the atomic industry. On view will be a wide range of products and services related to the atomic industry; its major components, auxiliary equipment, and many accessories. For further information write to the: Trade Fair Dept., Atomic Industrial Forum, 260 Madison Ave., New York 16, N. Y.

OCTOBER 1-3

12th Annual National Electronics Conference, Hotel Sherman, Chicago, Ill. More than 100 technical papers and 235 commercial exhibits will be featured at this forum on electronic research, development, and application. The conference is sponsored by the AIEE, IRE, Illinois Tech., Univ. of Illinois, and Northwestern University.

OCTOBER 3-5

Fifth Annual Meeting of the Standards Engineers Society, Hotel Willard, Washington, D. C. Theme will be "Standards–Guides for Tomorrow." Sessions are scheduled on standardization in the chemical industry, standards and the atomic energy field, future trends of standards in the metals field, creative engineering and standards, progress of engine standardization, and screw thread standardization from the viewpoint of the manufacturer.

OCTOBER 4-5

Annual Convention of the Magnesium Association, The Drake, Chicago, Ill. The meeting provides a platform from which current developments in magnesium use are presented and discussed by those using the metal in their production program.

OCTOBER 8-10

ASME Lubrication Conference, Chalafonte-Haddon Hall Hotel, Atlantic City, N. J.

OCTOBER 15-17

National Association of Corrosion Engineers, Drake Hotel, Philadelphia, Pa. Symposia on protective coatings, metals and alloys, cermets and plastics, and the use of statistical methods. Technical committee meetings will be held on the 15th.

OCTOBER 18-19

1956 National Conference on Industrial Hydraulics, Sherman Hotel, Chicago, Ill.

OCTOBER 28-31

Semi-annual meeting of the American Gear Manufacturers Association, The Edgewater Beach Hotel, Chicago, Ill. For further information write: John C. Sears, Executive Secretary, One Thomas Circle, Washington 5, D. C.

OCTOBER 30-NOVEMBER 1

Fall Meeting, National Fluid Power Association, Hotel Cleveland, Cleveland, Ohio. For further information write to the Association's Headquarters at 1618 Orrington Ave., Evanston, Ill.

OCTOBER 31—NOVEMBER 1-2

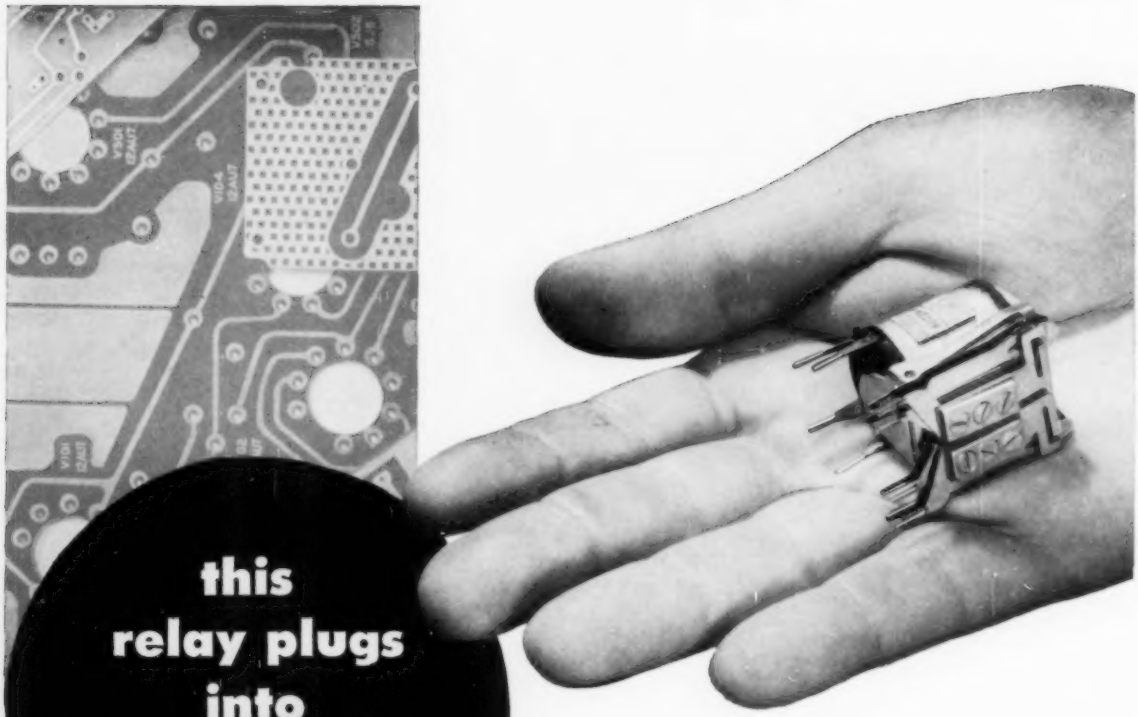
Society for Experimental Stress Analysis, Deshler-Hilton Hotel, Columbus, O.

NOVEMBER 26-30

22nd National Exposition of Power and Mechanical Engineering, Coliseum, New York City. During the week will be the 76th annual meeting of the ASME, including sessions of the Society's Nuclear Engineering Division. The 5th Annual Atomic Energy in Industry conference of the National Industrial Conference Board also will be held that week.

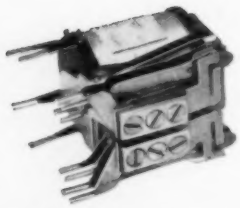
DECEMBER 10-12

1956 Eastern Joint Computer Conference, Hotel New Yorker, New York City. The meeting will be jointly sponsored by the IRE, AIEE, and the Association for Computing Machinery. The theme will be "New Developments in Computers." Besides an extensive program of technical papers, there will be many exhibits by manufacturers.



this relay plugs into printed circuits

. . . and runs up to 120 million operations without attention.



HELPFUL INFORMATION FOR THE TECHNICALLY MINDED . . .

Dimensions: Length, 1 3/4"; height, 1 5/16" to 1 3/4" (depending upon the number of contact springs); width, 1".

Operating Voltage: Up to 175 volts, dc, only.

Contact Spring Capacity: Maximum of 9 springs per pile-up.

Springs: Can be made of phosphor-bronze, "Bronco" metal, or other special purpose materials, as required.

A new stainless-steel armature bearing pin, a new sintered metal yoke, a new lubricating system for the armature—these features add up to 10 times the life of former relays. Automatic Electric Printed-Circuit Relays meet today's needs in automation, in computers, in any applications requiring utmost dependability.

Specially designed plug-in terminals are an integral part of the coil and of the contact springs. They make firm, tight, high conductivity connections with printed circuits—and may be permanently secured by using any recognized soldering technique.

Besides these features, you get efficient magnetic design, permanently welded contacts, "stay-put" contact springs and many other advantages found in all Automatic Electric relays. Save parts, assembly and wiring time by using printed circuits—and Automatic Electric Printed-Circuit Relays. For complete details, *write:* Automatic Electric Sales Corporation, 1033 West Van Buren Street (HAymarket 1-4300), Chicago 7, Illinois. *In Canada:* Automatic Electric Sales (Canada) Ltd., Toronto. *Offices in principal cities.*

AUTOMATIC ELECTRIC

Originators of the dial telephone · Pioneers in automatic control

GENERAL SYSTEM

Deflections of Cantilever Beams With Changing Cross Sections

W. R. LEOPOLD
Lycoming Division of the Avco Mfg. Corp.

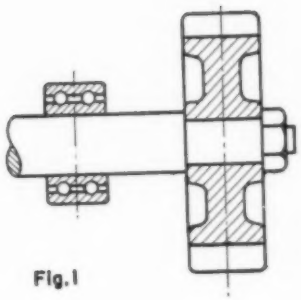
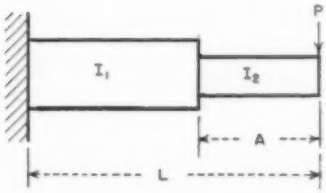


Fig. 1



$$\delta = \frac{P}{3EI_1}\left[L^3 - A^3 + \frac{I_1}{I_2}(A^3)\right]$$

Fig. 2 (A)

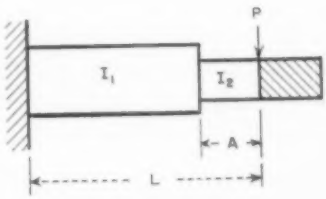
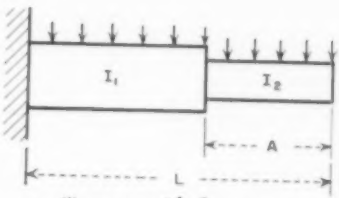


Fig. 2 (B)



$$\delta = \frac{W}{8EI_1}\left[L^3 + \frac{A^4}{L}\left(\frac{I_1}{I_2} - 1\right)\right]$$

Fig. 3

BEAMS HAVING TWO CROSS SECTIONS are commonly encountered in design of machinery. For example, gears, pulleys, sprockets and cams are sometimes mounted on the end of a shaft as shown in Fig. 1. The extension of the shaft can be treated as a cantilever beam if the slope of the shaft is approximately zero at the bearing.

Cantilever beam with a concentrated end load is illustrated in Fig. 2 (A); Fig. 4 is a nomogram for determining its deflection. For cases where load *P* is located midway along length *A*, as shown in Fig. 2 (B), the deflection at *P* can be approximated by adding to load P the weight of the shaft to the right (shaded section).

Young's modulus, *E*, has been assumed as 10,000,000 lb/in.^{2} for aluminum. For any other material and modulus, multiply the deflection obtained in the charts by the ratio 10,000,000/*E* (desired).

EXAMPLE: Given $I_1 = 4$ in.^{4}, $I_1/I_2 = 6$, $A = 6$ in., $L = 22$ in., $P = 400$ lb, $E = 10{,}000{,}000$ lb/in.^{2}

SOLUTION: Enter graph in Fig. 4 at $I_1/I_2 = 6$. Follow the red line through the given values to the deflection scale. Read $\delta = 0.040$ in.

Cantilever beam with uniformly distributed load is illustrated in Fig. 3; its deflection can be solved by using the nomogram in Fig. 5. Red line shows method of obtaining deflection of a beam having the following characteristics:

$I_1/I_2 = 5$, $I_1 = 8$ in.^{4}, $A = 7$ in.
$W = 3{,}000$ lb, $L = 22$ in.
$E = 10{,}000{,}000$ lb/in.

where W is total load due to the uniformly distributed load.

Deflection is read as 0.051 in. When E is 30,000,000 deflection becomes:

$$\delta = 0.051\left(\frac{10{,}000{,}000}{30{,}000{,}000}\right) = 0.017$$

Deflection can be further modified for other values of *I* and *P* by multiplying deflection by I/I(desired), or P(desired)/P.

Tapered beams closely approximated by two mements of inertia can also be solved by use of these charts.

For load valves not easily discernable on the charts, multiply or divide both load and resulting deflection by a multiple of ten.

(continued on page 217)

NOW–FOR IMMEDIATE DELIVERY...

VERSA CONTROL VALVES

... in Over 110,000 Variations!

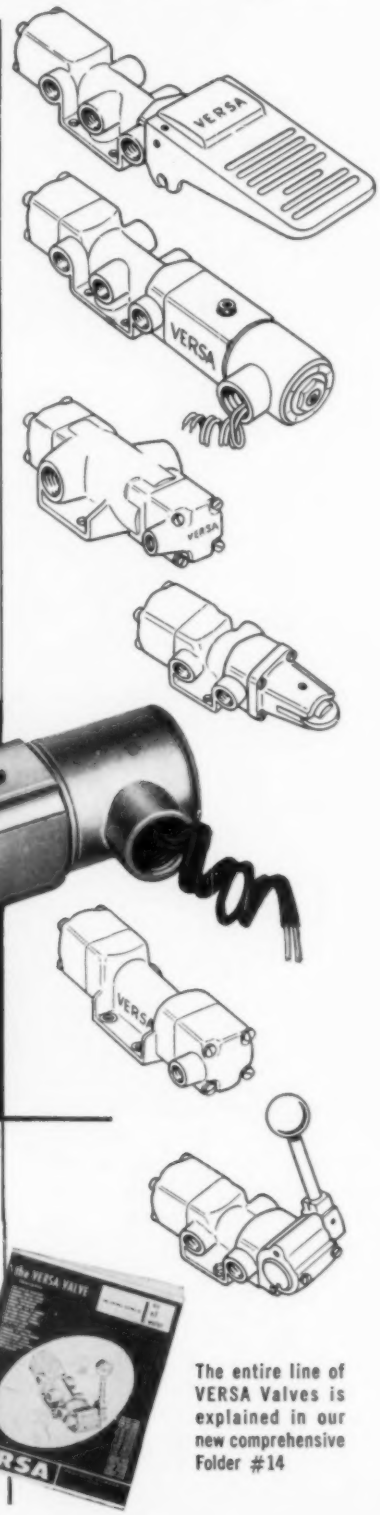
Versa Valves are available in 2-, 3-, 4-, and 5-way types with over 20 actuating devices, in sizes from ⅛" to 1" N.P.T., and for pressures from partial vacuum to 500 PSIG.

The entire line of Versa Valves (over 110,000 variations) are stocked by authorized Versa distributors, strategically located throughout the United States and Canada.

All Versa Valves are triple pressure and functionally tested under water for guaranteed leakproofness . . . actually exceed J.I.C. standards.

Write today for the name of your nearest Versa distributor. Remember, you can get immediate delivery of these rugged, compact control valves to fit your most exacting hydraulic or pneumatic requirement.

Cut-away view of VERSA Double Solenoid Valve, 4-way type.



VERSA

VERSA PRODUCTS COMPANY INC.
249 SCHOLES STREET
BROOKLYN 6, N. Y.

The entire line of VERSA Valves is explained in our new comprehensive Folder #14

Deflections of Cantilever Beams With Changing Cross Sections (continued from page 215)

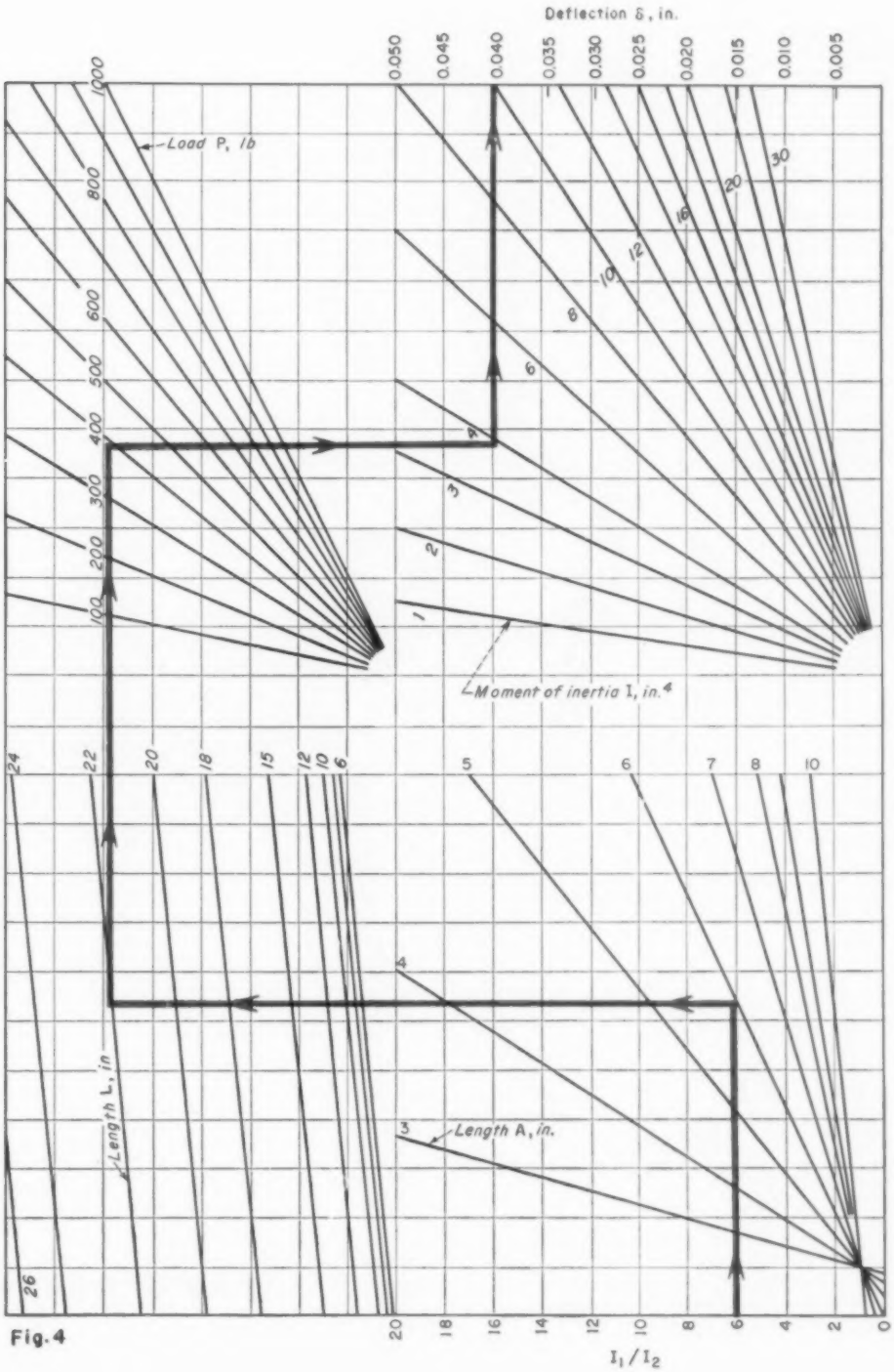


Fig. 4

(continued on page 219)

what is grey matter worth?

For the engineer or scientist who has enough to make him different, *grey matter* is worth a rewarding life of creative achievement in a working climate where ideas are King...and the benefits measure up to the man and his mind.

For 56 years Firestone has grown on *grey matter* – in Research, Development and Production. Now, simply, we need additional *grey matter* for such Firestone "firsts" as the "Corporal" surface-to-surface ballistic missile. Here are just a few of the Engineering activities in which Firestone needs more *grey matter:*

Electronics Systems
Mechanical Systems
Propulsion Components
Flight Simulation
Mechanical Structures and Dynamics
Stress Analysis
Metallurgical Lab

If you're the man with extra *grey matter* who wants the chance to really use it, write us today. We'll put you in touch with a Firestone man who has your kind of *grey matter*, too.

Firestone

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RESEARCH • DEVELOPMENT • MANUFACTURE

"Find your Future at Firestone"– Los Angeles • Monterey

WRITE: SCIENTIFIC STAFF DIRECTOR, LOS ANGELES 54, CALIF.

Deflections of Cantilever Beams With Changing Cross Sections (continued from page 217)

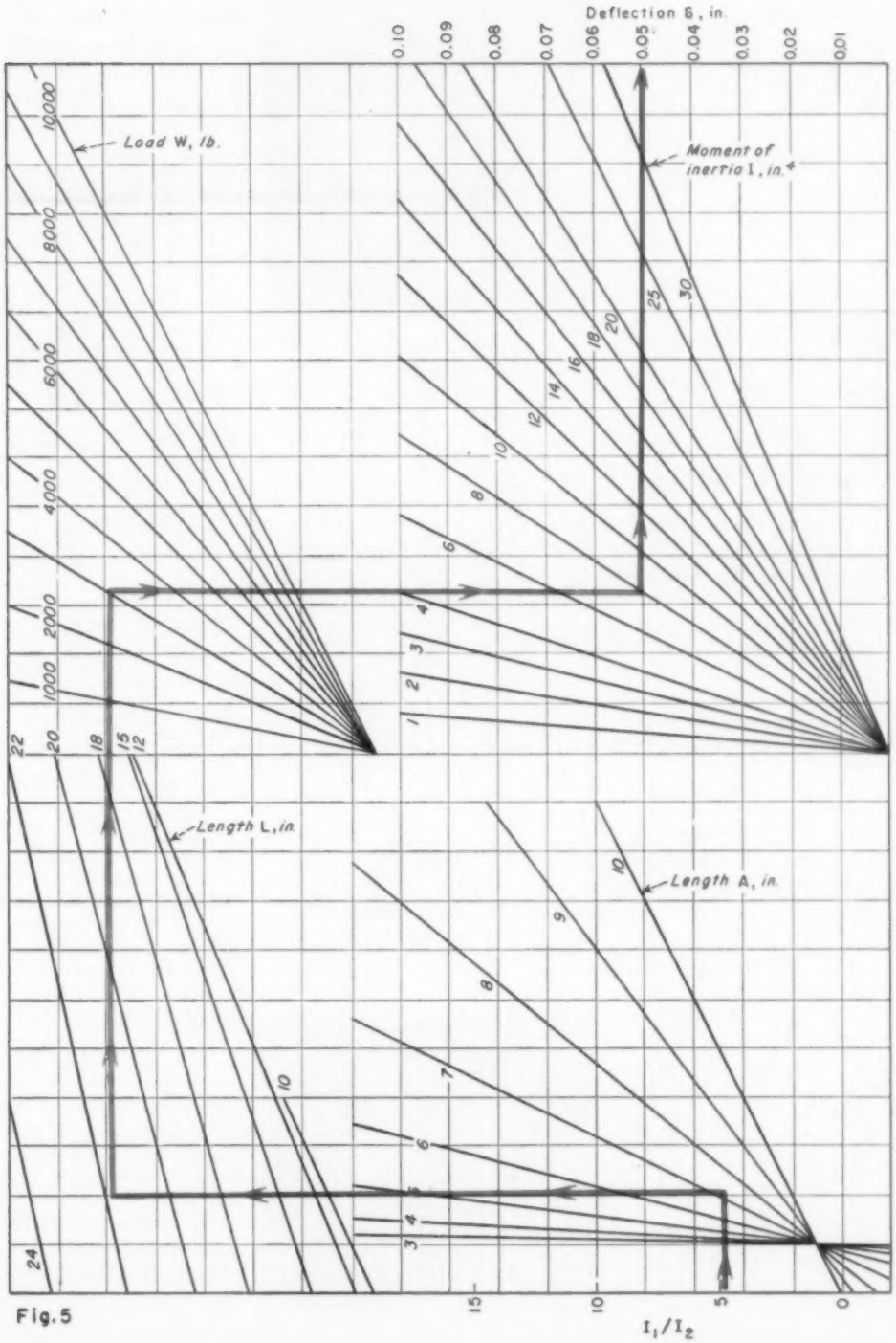
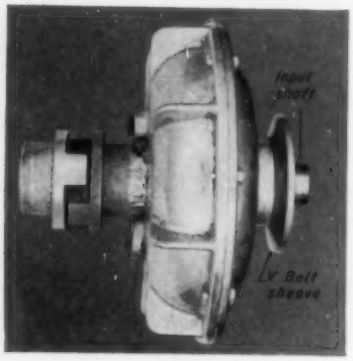
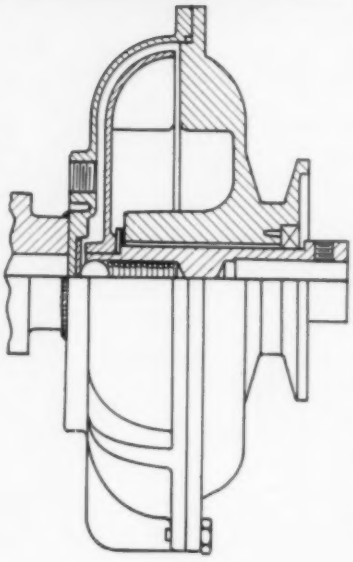


Fig. 5

NEW COMPONENTS

Hydraulic Coupling for Fhp Motors



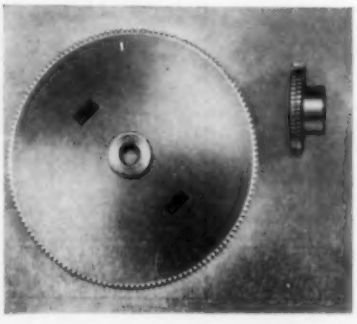


In this automotive type of fluid drive for fhp industrial applications, oil is continuously pumped from impeller to runner, so that power is transmitted through a slipping, fluid cushion. Built to develop up to ¾ hp at 1750 rpm continuously, the coupling is available with integral V-belt sheave or flexible coupling for direct drive. Either type is easily installed on a stub shaft; operates equally well in either direction and in any position.

The Model F has 7¼ in. OD, and weighs approximately 2 lb when filled with 12 oz of oil. The device can be applied to any equipment requiring absorption of running shocks and torsional vibrations, torque limitation, smooth starting or plug reversing, such as conveyors, baking ovens, door operators and cranes. Also used to provide uniform tension winding. Fluid Drive Engineering Co., 3105 E. Cheltenham Pl., Chicago 49, Ill.

For more information—
Circle 1, inside back cover

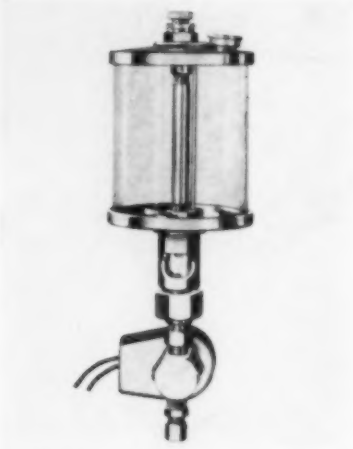
Anti-Backlash Gear Assemblies



Pitch diameters range from 1 to 2 in., available in 14½ or 20 deg pressure angles and in 48, 64, 72, 80, 96 or 120 pitch. Hubs are stainless steel and manufactured as clamp type and solid type. Available bore sizes are 0.125, 0.1875 and 0.250 in., with a +0.0005 in. tolerance. Face thickness is ⅛ in.

Gear blanks are 24ST aluminum. All blanks are centerless ground to insure maximum parallelism. Gears are cut to Class I tolerance; choice of Alodine or Anodize finish. Dynamic Gear Co., Inc., Amityville, N. Y.

For more information—
Circle 2, inside back cover



Flushing Drop Feed Oiler

These oilers automatically flood or flush a bearing with a definite amount of oil at the starting period, after which oil will feed drop by drop. The quantity of oil provided for flushing is fixed while drop feeding can be adjusted. After the oiler is shut-off it will automatically reset itself for the next operating period.

This particular unit is solenoid operated. The normally closed solenoid valve is usually wired across the line of the driving motor for automatic operation. Manual units can also be furnished. Oil-Rite Corp., 2382 Waldo Blvd., Manitowoc, Wis.

For more information—
Circle 3, inside back cover

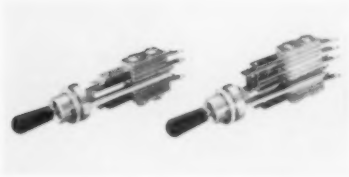
Barometric Switch

A new barometric switch which is operated by changes in altitude has been introduced for general electrical control in response to barometric changes. Weighing a few ounces and scarcely larger than a golf ball, a hy-

draulically formed, special bronze bellows with low hysteresis forms the heart of the unit, encased in a die-cast, anodized aluminum shell. The contacts are hermetically sealed and close with increase in pressure. The unit is temperature compensated.

Sensitivity is accurate to within 100 ft of altitude, with closer calibration and increased sensitivity available on special order. The switch rating is 3 amp at 24 v, dc, or 230 v, ac. Clifford Mfg. Co., Waltham, Mass.

For more information—
Circle 4, inside back cover



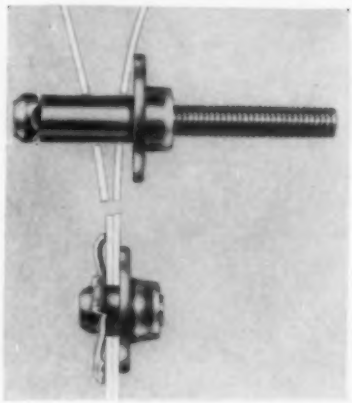
Single-Hole Mounting Switch

The switches have a mounting bushing $\frac{3}{8}$ in. long. This line is available in two and three-position types, both locking and non-locking. Switchcraft, Inc., 1328 N. Halsted St., Chicago 22, Ill.

For more information—
Circle 5, inside back cover

Blind Rivet Forms Own Retainer

The rivet is comprised of a hard aluminum pin with five cutting edges and a hard aluminum sleeve with large or small washer flange. It is inserted into a blind hole from the driving side and a simple tool pulls the pin head through the sleeve, splitting the sleeve into five powerful levers which spread and curl back against the blind side. This pulls the work together and holds it braced, over a large bearing area, in a permanent grip. In the same operation a swaging anvil flows the outer collar material into the locking grooves on the pin and breaks off the excess rivet pin, leaving a stub.



Because of the wide bearing surfaces of this rivet it is said to be usable without careful attention to hole size. Huck Mfg. Co., 2480 Bellevue Ave., Detroit, Mich.

For more information—
Circle 6, inside back cover

Hydraulic Governor

Rated work of this governor is 123 in.-lb, and rated torque is 159 in.-lb. Steady state stability is better than 0.1 per cent. Either isochronous or speeddroop characteristics are obtainable by manual adjustment. Adjustments provided include speed changer, steady-state speed regulation, first compensation relay, second compensation timing valve, rate of response and load limit throttling. A fail-safe flexible drive dampens speed variations without affecting performance.

All parts are interchangeable in the field to meet varying operating conditions. Industry standard or custom mountings are included as integral part of the unit's modern design. Farris Pickering Governor Co., Inc., 705 Commercial Ave., Palisades Park, N. J.

For more information—
Circle 7, inside back cover

Strain Cycle Counter

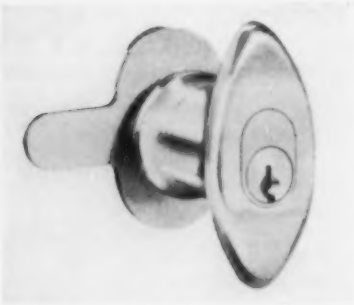
Strain cycles occuring within six different levels can be totaled with recording apparatus, which incorporates a self-balancing strain gage bridge, servo amplifier and counters to register strain cycles as low as 500 psi. Mechanical loading and fatigue data occuring in automotive equipment, aircraft, ships, railroad rolling stock and structures such as buildings, bridges and trestles can be collected under actual operating conditions. In all applications a transistor amplifier is used. Franklin Electronics Inc., Dept. 68, E. 4 St., Bridgeport, Pa.

For more information—
Circle 8, inside back cover

Knob-Type Cabinet Lock

The lock has a solid brass handle and escutcheon. Reversible for either right or left hand doors, the lock permits either 47 or 90 deg knob movement, either clockwise or counterclockwise. Plug and cylinder insert

CONTINUED ON PAGE 222



are easily removable for replacement or rekeying. Available with several different latch plates for variety of applications. National Lock Co., Rockford, Ill.

For more information—
Circle 9, inside back cover

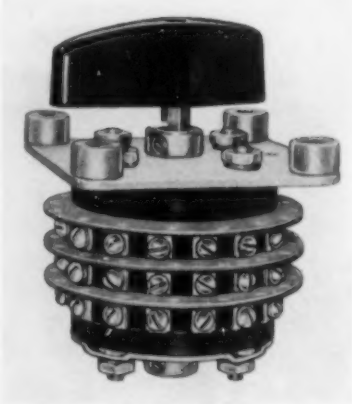
Coolant Pump Motors

A totally enclosed fractional-horsepower motor designed for machine-tool coolant pumps has the NEMA-C end-shield for direct coupling to the pump. The motor can be mounted horizontally or vertically. The motor is effectively cooled by conduction and radiation. Internal fans maintain even internal temperatures by circulating air to the cooler surfaces. Rated temperature rise is 55 C. General Electric Co., Schenectady 5, N. Y.

For more information—
Circle 10, inside back cover

Rotary Multi-Pole Switch

This switch is designed for tap, transfer and selector service requiring interrupting rating up to 5 amp, 125 v, ac. The make and break of the switching action is fully enclosed within the molded phenolic structure of each 16-contact section. The switch will carry 10 amp at 125 v, ac. All-silver contacts provide low contact resistance, 0.001 to 0.005 ohm.



The switch is panel mounting, requiring 3 x 3 in. It is furnished in standard sizes for mounting on $\frac{1}{8}$, $\frac{1}{4}$, $\frac{3}{8}$, $\frac{1}{2}$ or 1-in. thick panels. Electro Switch Corp., Weymouth 88, Mass.

For more information—
Circle 11, inside back cover

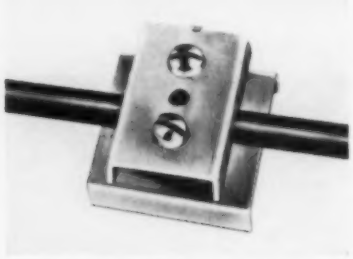
Soft Seal For Fuel

A synthetic rubber, developed for high temperature fuel service, is available in special molded shapes and bonded parts, as well as in standard O-ing seals. The compound remains flexible at −75 F. Parker Appliance Co., 17325 Euclid Ave., Cleveland 12, Ohio.

For more information—
Circle 12, inside back cover

Clamp for Flexible Remote Controls

A casing clamp which will take all flexible control casing from $\frac{3}{16}$ to and including $\frac{7}{16}$ in. dia can be used at both the control ends and at intermediate positions. The unit is mounted with two screws and will not swivel from its position. The construction is all-steel, cadmium–plated, and the clamps are available completely assembled or as separate stampings. They are not recommended for clamping tubing or electrical cables. Arens Controls, Inc., 2017 Greenleaf St., Evanston, Ill.



For more information—
Circle 13, inside back cover

Quick-Disconnect Coupling

This self-sealing hydraulic coupling locks with a simple push. There is no intermediate, or partially locked, position. It couples against 60 psi in both coupling halves without twisting, turning or special tools. Weatherhead Co., Antwerp, Ohio.

For more information—
Circle 14, inside back cover

Seal for Metal-to-Metal Joint

A piston seal has been developed for applications where flange parting surfaces must form a metal-to-metal joint. The seal is one of four distinct types of long stroke, deep convolution, constant area diaphragms. In design

CONTINUED ON PAGE 224

The Engineer from Continental Screw Co. ...

Brings you over 20 years' experience in aluminum fastenings

Long experience helps Continental advise you on aluminum fastener needs

You'll find a short talk about aluminum fasteners with Continental's engineers well worth your while. They pioneered in the development of these long-wearing, non-rusting lightweight fasteners and now offer you the largest range of sizes and types in the industry.

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Continental handles both aluminum nuts and screws, including wood screws, machine screws, and tapping screws. They will also match any color you wish for your aluminum fasteners. For the kind of service that comes from long experience in the field, call on the engineers from Continental.

Only Continental Engineers Are Required To Have This Training

Each engineer at Continental is required to undergo thorough experience producing ground thread taps and gages, with their exacting screw thread dimensions. This special training is passed on to you—at no extra cost.

CONTINENTAL SCREW COMPANY INC. 1904

—You can count on Continental.

Continental Screw Co.

Manufacturers of Holtite Fastenings

New Bedford, Massachusetts, U.S.A.

a flange is used with a clamping bead on its lower surface. Typical uses of a metal-to-metal flange contact include cases where through bolting would exert excessive forces, causing extrusion; where flange perforation and positioning over stud or tap holes would be awkward; or where uneven clamping forces result in an undesirable nonparallel condition between the cylinder and its mating part.

The seals are available in more than 80 standard sizes, for bores from 1 to 6 in. dia. Elastomer-fabric combinations range from nitrile rubber and Nylon to silicone rubber and Dacron. Bellofram Corp., Burlington, Mass.

For more information—
Circle 15, inside back cover

Screen Process Kit

The duplication of printed circuits, nameplates, dials or other line work reproduction in prototype or quantity amounts is possible with this one complete package of all the necessary materials and information. This screen processing kit consists of resist ink, squeege, film and chemicals, as well as several instruction brochures. Techniques, Inc., 178-184 Central Ave., Hackensack, N. J.

For more information—
Circle 16, inside back cover

O-Ring Compound for —65 F to 275 F

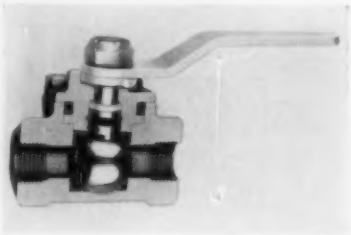
The compound is reported to meet the requirements of high temperature systems in sonic military aircraft operating with MIL-O-5606 hydraulic fluid. It meets MIL-P-18017B(ASG) and its predecessor specifications. Precision Rubber Products Corp., 3114 Oakridge Dr., Dayton 7, Ohio.

For more information—
Circle 17, inside back cover

Elliptical Self-Locking Nut

A lightweight hex nut that can be wrenched internally or externally has an internal wrench adapter intended for use especially where space is at a premium and there is insufficient clearance for wrenching in the conventional external manner by sockets or open end wrenches. This nut may be nestled closer to adjoining structure and spot face diameters and flange widths may be substantially reduced. They are made in a complete range of sizes, from No. 4-40 through No. $\frac{7}{16}$-24. Kaynar Co., Box 2001, Terminal Annex, Los Angeles 21, Cal.

For more information—
Circle 18, inside back cover



Forged Ball Valve

The round opening in the ball is said to allow piping to handle fluids with minimum turbulence. Wiping action occurs on both sides of the ball. There is a material choice of naval bronze, aluminum bronze and aluminum permitting use with air, butane, propane, freon, gases, hydrogen, oxygen, salt water, petroleum oils. Seating materials available are Buna-N, Neoprene, natural rubber, Hypalon, Teflon. Valve is maintained without removing from the line. Worcester Valve Co., Inc., Worcester, Mass.

For more information—
Circle 19, inside back cover

Spray Application of Cutting Oils

This system applies a more uniform and higher quality spray of cutting oil directly upon the close interfaces between the tool and work piece. It can be directed from the underside of the curled chip or from any other angle that will best reach the critical lubrication points.

The oil spray is produced within the nozzle itself, by means of a tube within a tube. The spray is delivered to the cutting area as soon as the machine is turned on. The liquid filter is located inside the reservoir. An average size unit occupies a space 14 x 20 x 7 in. with a 2 gal liquid reservoir. C. A. Norgren Co., 3499 S. Elati St., Englewood, Colo.

For more information—
Circle 20, inside back cover

Wire-Wound Controls for Printed Circuits

Mounting is by two tabs for positive locking to printed-wiring board. Control is rated at 2 w. Resistance range from 4 to 5000 ohm. Control measures $\frac{3}{4}$ x $\frac{3}{8}$ in. deep. Clarostat Mfg. Co., Inc., Dover, N. H.

For more information—
Circle 21, inside back cover

Flareless Tube Fitting

Designed for use with the new SAE O-ring boss, this fitting withstands higher operating pressures without the use of backup rings. The O-ring seal is also designed for air application and tested to operate at temperatures from —65F to 212F.

Intended for high-pressure systems, the fitting is stocked in 31 different styles and in sizes from $\frac{1}{8}$ to 2 in. Weatherhead Co., 128 W. Washington Blvd., Fort Wayne, Ind.

For more information—
Circle 22, inside back cover

Flow Control Valves

These valves are intended for applications that require either manual or automatic valving of air, water, oil or freon. A single basic valve body may be used either normally open or normally closed, depending upon port connections. To this standardized valve body may be added a variety of simple devices for triggering the valve action. Seven models are currently

CONTINUED ON PAGE 226

pre-planned

In estimating production costs, one of the items a metal fabricator takes into account is the cost of steel. As important as this is, it is sometimes good economics to pay more for steel, but pay less in the end for the fabricated part. The cost of down time on expensive forming equipment, the cost of idle labor, the cost of reprocessing defective parts, may well exceed the cost of the extras built into restricted specification steel, which will eliminate these unplanned-for costs.

CMP restricted specification cold rolled strip steel can be pre-planned to minimize production delays and produce for you the production cost you need. We will welcome the opportunity to explore with you the cost-saving potentials in your manufacturing processes which may be available to you by use of **CMP** restricted specification cold rolled strip steel.

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results

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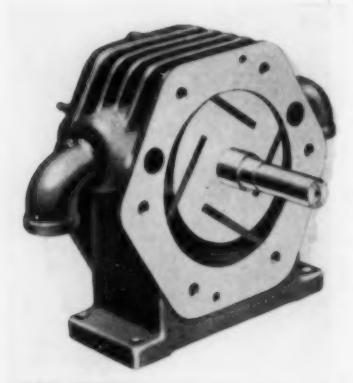
STRIP PROVIDES the precision dimensional and physical qualities that solve many fabrication, cost and performance problems.

available—solenoid, cam-operated palm button, finger-tip, foot operated and two types with hand lever.

Opening, closing and holding action are effected by the pressure of the air or liquid. The valve body is machined from steel bar stock and is equipped with Buna-N rubber diaphragms. Valve is adapted for applications up to 125 psi and under temperature variations from—40F to 225F. Humphrey Products, subsidiary, General Gas Light Co., Kalamazoo, Mich.

For more information—
Circle 23, inside back cover



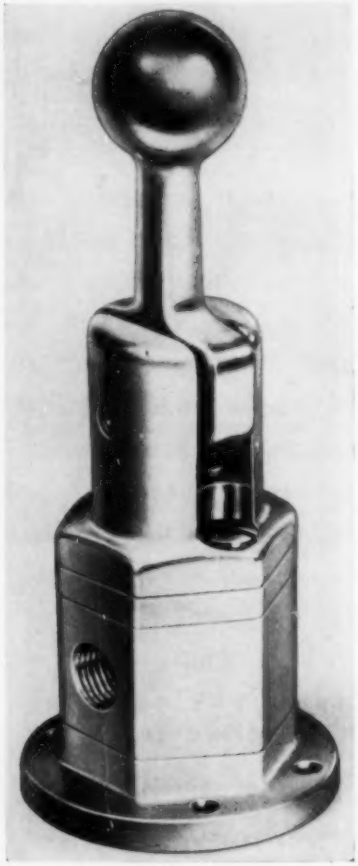
Bronze Rotary Pump

This pump is for vacuum and/or pressure applications in handling steam, hydrogen, natural or manufactured gas, nitrogen or other inert gases carrying entrained moisture. The bronze construction of rotor and housing is said to eliminate "freezing", due to water-vapor corrosion at the limited-clearance rotor extremities and housing end-plates.

The sintered carbon vanes require no lubrication in riding against the cylinder wall. There is no reciprocating motion and the pump is pulseless and vibrationless, delivering an even flow of air and eliminating the need for surge tanks.

The pump is available in three models, and capacities range from 3.5 to 33 cfm and maximum continuous pressure is 20 psi. Maximum steady vacuum is to 20 in. Hg and maximum intermittent vacuum is 25 in. Hg. Dexter Folder Co., Pearl River, N. Y.

For more information—
Circle 24, inside back cover



Pilot Valves

The available models include hand, foot, palm-button, cam and solenoid-actuated types. The hand valve is available in either locking or non-locking type. Valve may be used singly or in series for working pressures up to 150 psi. Various mountings are available. Mechanical Air Controls, Inc., 10030 Capital, Oak Park, Detroit 37, Mich.

For more information—
Circle 25, inside back cover

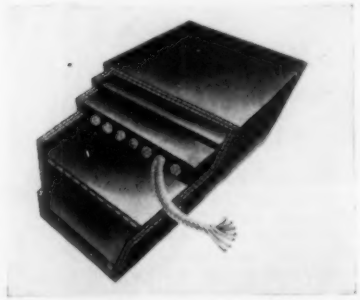
Two-Way Solenoid Valve

All control parts can be removed as one assembly without disturbing the piping and by loosening one hexagonal nut. Primarily for a-c applications (both pressure and vacuum) this normally closed valve is available in standard pipe sizes from ¼ through 2 in. Airmatic Valve, Inc., 7317 Associate Ave., Cleveland 9, Ohio.

For more information—
Circle 26, inside back cover

Steel Cable V-Belts

The belts are reinforced with a steel cable which is reported to make possible heavier loads with smaller sheaves or fewer belts. Each cable strand is made of plated brass-plated



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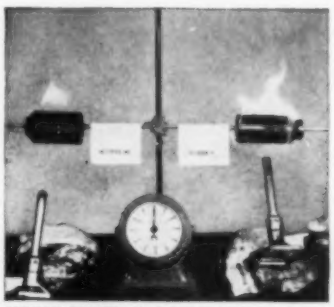
Using

DU PONT ELASTOMERS

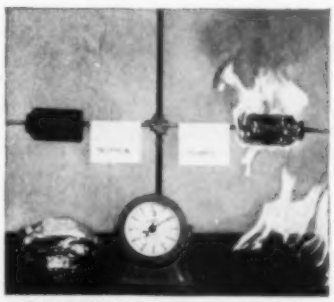
NEOPRENE - HYPALON®

4 in Design

NEOPRENE ROLLERS PASS FLAME TEST!



PRINTING ROLLERS of neoprene (left) and natural rubber (right) are exposed to the flame of Bunsen burners until they ignite.



IN FIVE SECONDS after burners are removed, flame on neoprene roller is out. After 69 seconds, drippings from flaming rubber roller have ignited newspaper.

This test convinced management of the New York *Daily News* that neoprene printing rollers offer an extra measure of safety over natural rubber. Today, they flame test all rollers before they buy—and neoprene rollers are the only rollers that meet the test.

Neoprene's resistance to flame may well be useful to you as an added safety factor in your product designs. And neoprene offers resistance to abrasion, oil, heat, and chemicals as well. For all general-purpose applications, you can count on neoprene for long-term service. Clip coupon for further information.

Resilient gaskets of HYPALON® unaffected by 2% ozone

Re-usable after 2 years in ozone generators

For two years now Emery Industries has been using HYPALON synthetic rubber gaskets to seal its ozone generators. The company's ozone-producing installation is the largest in the country. Its operations supervisor, Robert Peters, made this report on HYPALON. "No failures with HYPALON gaskets in two years, even though they've been exposed to 2% ozone."

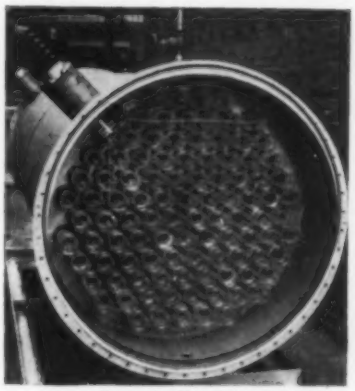


Photo courtesy Welsbach Corp., Phila., Penna.

HYPALON gasket on ozone generator showed no sign of deterioration after two years of service.

Design of the generator

The generator used by Emery Industries consists of a steel shell packed with a series of glass tubes individually encased in an electrically charged metal enclosure. A conductor carries an opposing charge through the glass tubes to make, in effect, a large electrical condenser. Dry oxygen is passed along the length of the glass tubes and converted to ozone. The generators are closed at each end by a dished head sealed with HYPALON gaskets.

HYPALON replaces plastic

Formerly, plastic gaskets were used in the generator. While unaffected by ozone, plastic gaskets had to be replaced after each maintenance checkup because they were too rigid for re-use. HYPALON gaskets, even after two years of service, retain their resilience and are still re-usable. Says the generator manufacturer, Welsbach Corporation, in Philadelphia: "We use HYPALON gaskets because they have the best over-all combination of properties of any we've found—including ozone inertness, resilience and cost."

Designing with HYPALON

HYPALON means extra-long life at lower operating costs for resilient products subject to severe service conditions. It can operate at temperatures from 250°F. to 350°F. It is particularly resistant to most oxidizing chemicals. And HYPALON resists weather and sunlight attack and can be compounded in an unlimited range of stable colors. For more information about HYPALON, clip and mail the coupon below.

DU PONT

HYPALON *is a registered trademark of E.I. du Pont de Nemours & Co. (Inc.)*

BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

Please send further information and add my name to the mailing list for your free publications, the "Neoprene Notebook" and "Facts about HYPALON®," which show how the Du Pont elastomers are used in designing new products, improving old.

E. I. du Pont de Nemours & Co. (Inc.)
Elastomers Division, Dept. PE-7
Wilmington 98, Delaware

Name_____ **Position**_____

Firm_____

Address_____

City_____ **State**_____

steel, with a specially-treated coating. The belts are for installations where diameters, widths and centers of sheaves are restricted. Durkee-Atwood Co., Minneapolis 13, Minn.

For more information—
Circle 27, inside back cover

Snap-action Thermostat

A thermostat designed for appliances requiring positive snap-action will "remake" with a predetermined differential. Metal-to-metal contact with the heated surface minimizes the differential between operating and bimetal temperatures.

The thermostat can be obtained in any calibration up to 550 F. It has a rating of 1500 w on 115 or 230 v with limited d-c ratings. Westinghouse Electric Corp., P. O. Box 2099, Pittsburgh 30, Pa.

For more information—
Circle 28, inside back cover

Positive-Seal Bearing

A pillow block and flanged mounting for ball bearings are of the eccentric lock type. They are suited for applications where pedestals are not available and the bearing housing must be mounted at right angles to the shaft. Bolt holes on both types are spaced to allow the units to be interchangeable with mountings of similar design. Skf Industries, Inc., Front St. and Erie Ave., Philadelphia 32, Pa.

For more information—
Circle 29, inside back cover

Relay of 1.5 Amp Capacity

The relays are designed to operate on as low as ½ w coil power with transit times as low as 3.5 millisec. Contact capacity is 1.5 amp inductive at 200 v, ac or dc. Adjustable contacts are normally set for pull-in current of 7.2 milliamp, max, and drop out current of 4.8 milliamp, min.

Available as single-pole, single-throw, open type, or double-pole, double-throw, or in a tandem arrangement consisting of two relays on the same base. Unit is also available hermetically sealed. Coil value is 5000 ohm for nominal 30 v, d-c operation. Overall dimensions are approximately 1 x 1¼ x 1½ in. Radar Relay, Inc., 2120 Pontius Ave., Los Angeles 25, Calif.

For more information—
Circle 30, inside back cover

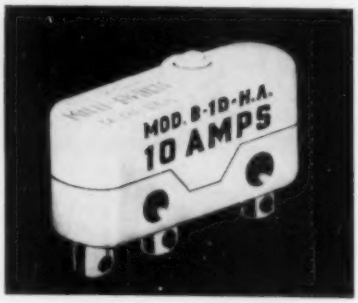
Flexible, Thin-Walled Tubing

Thin-walled and spaghetti tubing made of Teflon can be furnished from stock in a variety of sizes—any desired color available. Electrical, processing, instrumentation are among suggested applications. Sparta Mfg. Co., Dover, Ohio.

For more information—
Circle 31, inside back cover

Subminiature 10 Amp Switch

This switch is rated at 10 amp at 30 v, dc, resistive or 8 amp at 30 volts, dc, inductive. Maximum movement differential is 0.0015 in.; 0.008 in. pretravel; temperature range of −67 F to 300 F. Plastic case measures ¼ x ⅜ x ⅝ in. long, the terminals are



24 k gold plated over silver plate. The fine silver contacts and rivets are also 24 k gold plated.

Switches are furnished single-pole, double-throw, with one circuit normally closed. Milli-Switch Corp., 1742 Berkeley St., Santa Monica, Calif.

For more information—
Circle 32, inside back cover

Hydraulic Directional Control Valve

A line of two-way, solenoid-operated shut-off valves for 3000 psi service is offered by Aircraft Products Company. Designed for extremely low leakage in the closed position, sizes are available as standard for ¼, ⅜, or ½-in. hydraulic tube systems. They are available in normally open or normally closed types.

Series 6100 is basically a ⅜ in. valve, also available with ¼ in. ports; Series 6200 which is basically a ½ in. valve, also available with ⅜ in. ports. Temperature range is −65 F to 160 F standard; solenoid is continuous

CONTINUED ON PAGE 230

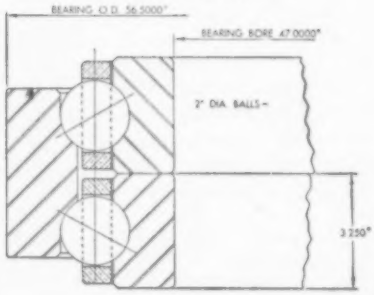
Here are the bearings that "couldn't be built"... *as produced by Kaydon*

THE manufacturer who wanted these bearings had been told they "couldn't be built." Or at least that's what he'd been told *until* he contacted **KAYDON**. What he required was a bearing 56½" in diameter combining high capacity, and exceptional precision for concentricity and face run[illegible] that would fit in limited space.

KAYDON designed a double-row angular contact ball bearing (see sketch at right). Actual tests have proved that the bearing fulfills every requirement.

If your designs require bearings of exceptional capacity, close-tolerance precision and/or very thin section — it will pay you to contact **KAYDON** of Muskegon. **KAYDON** has a long-standing reputation for accomplishing the near impossible.

CROSS SECTION — *The bearing that couldn't be built*



Just Out! Get your copy of the new **KAYDON** *Reali-Slim thin bearing catalog No. 54.*

THE KAYDON ENGINEERING CORP.

MUSKEGON • MICHIGAN

KAYDON Types of Standard and Special Bearings: Spherical Roller • Taper Roller • Ball Radial • Ball Thrust • Roller Radial • Roller Thrust • Bi-Angular Bearings

K843

PRECISION BALL AND ROLLER BEARINGS

duty, single coil. Operating range: 18 to 30 v, dc. Weights: Series 6100, 1.40 lb; Series 6200, 1.47 lb. Aircraft Products Co., 300 Church Road, Bridgeport, Pa.

For more information—
Circle 33, inside back cover

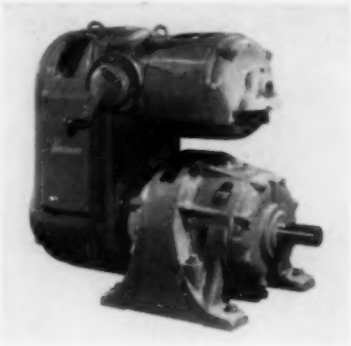
High-Speed Relay

A relay designed for dry-circuit and low power applications is unaffected during shock of 30 G, and vibration (10-55cps) of 10 G. Typical performance characteristics include: temperature range, −55 C to 100 C; contact ratings, up to 28 v, 200 ma; pull-in time (including bounce), as low as 200 microsec; drop-out time, 300 microsec; stray contact capacitance, less than 15 mmfd. Bristol Co., Waterbury 20, Conn.

For more information—
Circle 34, inside back cover

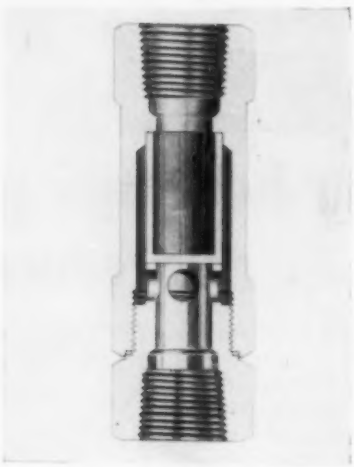
Variable Speed Motor

A variable speed, internally-geared motor, with take-off shaft and motor on the same side, is planned for low-speed applications requiring variable speed, where weight distribution and limited space is a factor. The units are available up through 5 hp. Both upright and horizontal assemblies are



on production with either dripproof, totally-enclosed or explosion-proof motors. U. S. Electrical Motors Inc., Box 2058, Terminal Annex, Los Angeles 54, Calif.

For more information—
Circle 35, inside back cover



Pipe Line Filters

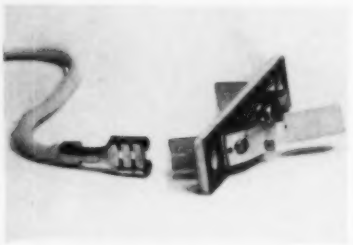
A series of brass and stainless steel line filters are used in conjunction with any valve handling small flows if foreign dust or particles in the fluid stream tend to clog the throat, change the effective opening, or obstruct full closing of the valve.

The two types are equipped with a replaceable bronze filter element capable of filtering out particles larger than a 5 to 12 micron range. The filters are available in two female pipe sizes: $\frac{1}{8}$ and $\frac{1}{4}$ in. Hoke, Inc., 197 S. Dean St., Englewood, N. J.

For more information—
Circle 36, inside back cover

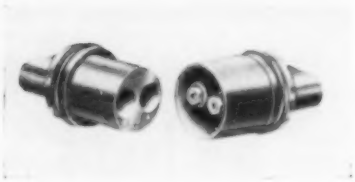
Quick-Connect Snap-Action Switch

An open-type switch is now available with quick-connect terminals. Mounting holes are on $1\frac{3}{4}$ in. centers. The switch is available in many



combinations of actuator arm configurations, operating forces, and electrical ratings to 10 amp, $\frac{1}{2}$ hp. Cherry Electrical Products Corp., 1650 Deerfield Road, Highland Park, Ill.

For more information—
Circle 37, inside back cover



Pressurized High Voltage Connectors

Connectors in two and three contact models designed for AN 24 shell were developed for altitude applications where leads are required for pressure-tight instrumentation. Maximum air leakage between contacts and insert, and insert and shells, is less than 1 cu in. of air per hr at an ambient temperature of 25 C centigrade when the plug is subject to a pressure differential of 30 psi. DeJUR-Amsco Corp., 45-01 Northern Blvd., Long Island City 1, N. Y.

For more information—
Circle 38, inside back cover

Centrifugal Pumping Units

Models of $\frac{1}{3}$ and $\frac{1}{2}$ hp are presently available. Unless otherwise specified, motors furnished are 3450 rpm, 60

CONTINUED ON PAGE 232

On materials handling machines used by

Hyster

Baker-Raulang

modern farmers ... by the armed forces ...

Prime Mover

Gerlinger

and by all branches of industry ...

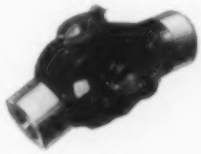
Towmotor

BLOOD BROTHERS UNIVERSAL JOINTS

are first choice!

On all kinds of materials handling equipment, dependable Blood Brothers Universals have won "first choice" reputations. This success results in part from close cooperation between our engineers and the men who design the machines . . . with the mutual goal of superior performance for the end user.

When you have a power transmission problem — large or small — contact Blood Brothers' engineers for suggestions. They'll gladly work with you . . . just write or call.



BLOOD BROTHERS MACHINE DIVISION

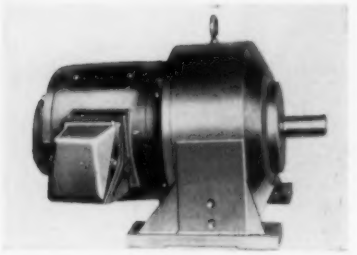
ROCKWELL SPRING AND AXLE COMPANY

ALLEGAN, MICHIGAN

UNIVERSAL JOINTS AND DRIVE LINE ASSEMBLIES

cps, single-phase. The mechanical seals used are self-adjusting, self-lubricating and easily replaced. Closed type balanced impellers are standard. Taco Heaters, Inc., 1160 Cranston St., Cranston, R. I.

For more information—
Circle 39, inside back cover



Gearmotors Rated At 1 to 60 Hp

Gearmotors are available in both ac and dc from 1 through 60 hp. Two-way seals lock oil in and seal dirt out so that the gearmotors may be mounted in virtually any position without leakage. A wide selection of mountings, enclosures, and ratios are available. Reliance Electric & Engineering Co., 1088 Ivanhoe Road, Cleveland 10, Ohio.

For more information—
Circle 40, inside back cover

Silicon Power Diodes

These diodes are rated for 300 ma, d-c rectified, output current when mounted by leads in free air at ambient temperatures up to 100 C. When mounted on cooling fins, the diodes can be rated for 1.25 amp rectified output current at a case temperature up to 150 C. The peak inverse voltage ratings range from 50 to 600 v.

The silicon power diodes are now available in two styles—standard power supply types for industrial applications and magnetic amplifier types for special low leakage applications. There are two current ratings for each style. They are also available in both the pigtail lead and stud mounted constructions. International Rectifier Corp., El Segundo, Calif.

For more information—
Circle 41, inside back cover

Plastic Hose

Designed and developed for compressed air and oil at working pressures up to 125 psi with an actual bursting pressure at 75 F of 600 psi. Either re-usable or permanent hose fittings can be used. Available in $\frac{5}{16}$, $\frac{3}{8}$, $\frac{3}{4}$, and $\frac{1}{2}$ in. ID sizes, carried in stock in 100 ft coils with or without fittings. Hoffman Engineering Co., 5601 S. Crawford Ave., Chicago 29, Ill.

For more information—
Circle 42, inside back cover

Miniature Accelerometer

A miniature accelerometer of the variable reluctance type allows measurement of accelerations from static to vibration frequencies as high as 1000 cps for the 300 G instrument. Other applications include measurement and control with indicating, recording and control systems adapted to operation with variable reluctance type transducers.

The device is available in ranges from ±5 to ±300 G. The unit weighs 1 oz. and is in the form of a cube $\frac{3}{4}$ in. on a side. Output is 40 mv/v input for full scale input and the accuracy is better than 1 per cent under constant conditions. North American Instruments, Inc., 2420 N. Lake Ave., Altadena, Calif.

For more information—
Circle 43, inside back cover

Subminiature Potentiometer

This $\frac{1}{2}$-in. dia, wire-wound potentiometer operates from −55 C to 150 C. Resistance range is 200 to 250,000 ohm, ±2 per cent. Linearity ±3 per cent. Weight is $\frac{1}{4}$ oz. Ace Electronics Associates, 103 Dover St., Somerville 44, Mass.

For more information—
Circle 44, inside back cover

Single Junction Silicon Rectifiers

Five production types of silicon rectifiers, having a single grown junction element with 1500 v breakdown voltage, are available with stable operation up to 150 C and forward current ratings up to 100 ma. These rectifiers are expected to have wide application wherever there is a need to miniaturize high voltage power supplies. Available in two types of axial and stud half-wave models and a full-wave plug-in model, these hermetically sealed rectifiers eliminate the need for filament power.

All rectifiers are heat cycled from −55 C to 75 C with 95 per cent humidity four times and from −55 to 150 C for four additional cycles to insure maximum reliability, stability, and long life under extreme environmental conditions. Texas Instruments Inc., 6000 Lemmon Ave., Dallas 9, Texas.

For more information—
Circle 45, inside back cover

Straight-Through Shut-Off Valve

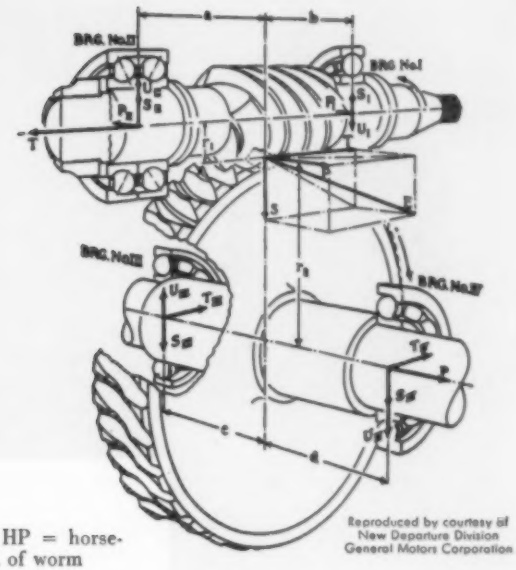
The valves have been used with liquid oxygen, jet fuels, high pressure pneumatic systems and hydraulic fluids. The self-cleaning seat arrangement

CONTINUED ON PAGE 234

(Advertisement)

Helpful Data from
DE LAVAL

How to Calculate Worm Gear Bearing Loads



Reproduced by courtesy of New Departure Division General Motors Corporation

$Q = \dfrac{HP \times 63025}{N}$ = TORQUE INPUT to worm, lbs. inches; HP = horsepower transmitted and N = rev. per min. of worm

$P = \dfrac{Q}{r_1}$ = TANGENTIAL FORCE of worm, where

r_1 = Pitch radius of worm in inches
[r_2 = Pitch radius of worm gear
$= \dfrac{1}{2\pi}$ (number of teeth in gear x axial worm pitch)]

$S = \dfrac{P \tan \alpha}{\tan \gamma}$ = SEPARATING FORCE, where
α = Axial tooth pressure angle*
γ = Helix or lead angle of worm*
$= \tan^{-1} \dfrac{\text{lead}}{2\pi r_1}$, or $\tan^{-1} \dfrac{\text{Number of threads x axial worm pitch}}{2\pi r_1}$

$T = \dfrac{P}{\tan \gamma}$ = WORM THRUST, or tangent force driving worm gear

*LEAD ANGLE 0°-35° use 27½° Pressure Angle
LEAD ANGLE 35°-45° use 30° Pressure Angle

BEARING LOADS

Due to	on Brg. I	on Brg. II
P	$P \dfrac{a}{a+b} = P_I$	$P \dfrac{b}{a+b} = P_{II}$
S	$S \dfrac{a}{a+b} = S_I$	$S \dfrac{b}{a+b} = S_{II}$
T	$T \dfrac{r_1}{a+b} = U_I$	$T \dfrac{r_1}{a+b} = U_{II} = U_I$
Total Rad. Load	$\sqrt{P_I^2 + (S_I - U_I)^2}$	$\sqrt{P_{II}^2 + (S_{II} + U_{II})^2} = R_{II}$
Thrust Load		T
Total Load	$\sqrt{P_I^2 + (S_I - U_I)^2}$	$\sqrt{R_{II}^2 + T^2}$

Due to	on Brg. III	on Brg. IV
P	$P \dfrac{r_2}{c+d} = U_{III}$	$P \dfrac{r_2}{c+d} = U_{IV} = U_{III}$
S	$S \dfrac{d}{c+d} = S_{III}$	$S \dfrac{c}{c+d} = S_{IV}$
T	$T \dfrac{d}{c+d} = T_{III}$	$T \dfrac{c}{c+d} = T_{IV}$
Total Rad. Load	$\sqrt{T_{III}^2 + (U_{III} - S_{III})^2}$	$\sqrt{T_{IV}^2 + (S_{IV} + U_{IV})^2} = R_{IV}$
Thrust Load		P
Total Load	$\sqrt{T_{III}^2 + (U_{III} - S_{III})^2}$	$\sqrt{R_{IV}^2 + P^2}$

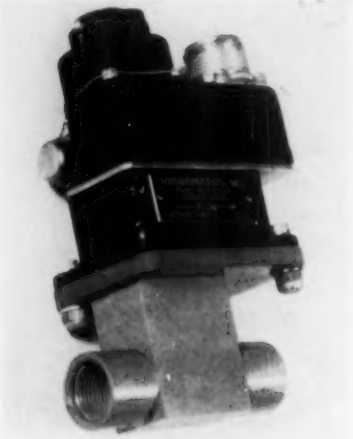
Speed Change

$$\text{Gear rpm} = N \times \frac{\text{Number of threads in worm}}{\text{Number of teeth in gear}}$$

For simplicity in bearing load computations for worm gearing, the normal tooth force E is treated in terms of its three perpendicular elements, namely, P, the tangential driving force at pitch radius of worm; S, the force tending to separate worm from the gear, due to the pressure angle; and T, the thrust produced by the lead or helix angle of the worm.

If you have a problem in the selection or application of worm gearing, De Laval engineers will be glad to put their experience to work for you. Either write us giving complete details, or consult your local De Laval representative. De Laval Steam Turbine Company, 801 Nottingham Way, Trenton 2, New Jersey

DL 848



is said to provide a bubble-tight seal in temperatures −320 F to 350 F and pressures from vacuum to 3000 psi. Valves are powered by either solenoid or motor actuators that automatically shut off current when cycle is completed. Available operating time range is from 0.030 to 1.0 sec. This valve is made in ¼, ⅜, ½, ⅝, ¾, 1 and 1¼ in. tube sizes. Hydromatics Inc., Cedar Grove, N. J.

For more information—
Circle 46, inside back cover

Self-Locking Screw and Bolts

The design of these socket-head fasteners makes use of the resilient properties of nylon to provide self-locking action on threaded fasteners which might otherwise loosen under the severe vibration to which many screws are subjected. A nylon pellet is inserted in a hole drilled part way through the threaded portion of the bolt. When the bolt is installed in a tapped hole or a standard nut, the exposed portion of the nylon pellet is compressed between the mating threads. In an attempt to regain its original shape, the nylon forces the threads together under pressure.

The nylon is reported to retain its resilience in the temperature range −70 F to 300 F, even through repeated uses. The fasteners will be available in a range of sizes from No. 6 upward. Standard Pressed Steel Co. Jenkintown, Pa.

For more information—
Circle 47, inside back cover

Low Sensitivity Relay

Incorporating a complete wiping action with sensitivity as low as 5 milliwatt per contact, this relay is designed for d-c applications. Capacity on the contacts is 1 amp inductive, or 5 amps resistive. Available coil resistance is up to 30,000 ohm. Contacts are available in either silver, palladium, gold alloy or alloy variations of these. Relay comes either hermetically sealed, dust cover or open. Dimensions: 1¼x3¾ in. above mounting line. Hedin Tele-Technical Corp., 87 Dorsa Ave., Livingston, N. J.

For more information—
Circle 48, inside back cover

Hydraulic Actuator For 800 F

This synchronous actuator, permits hydraulic operation in areas exceeding 800 F. To obtain this high temperature service, fluid is said to be kept constantly circulating through the system, with the flex shafting connections being constantly bathed in oil. Metal-to-metal contact is employed with precision matched fitting held to close tolerances. Applications are expected wherever linear movement from a single actuator or synchronized movement between two or more elements is required for operation in extreme temperature ranges. National Water Lift Co., Div. of Cleveland Pneumatic Tool Co., 2220 Palmer Ave., Kalamazoo, Michigan.

For more information—
Circle 49, inside back cover

Subminiature Tantalum Capacitors

The capacitors are designed and developed for transistorized electronic equipment.

Three nominal sizes are available: 0.095x¼ in.; ⅛x$\frac{5}{16}$ in.; ⅛x½ in. long. These cover a range of capacitance from 0.02 to above 30 mfd. Ohmite Mfg. Co., 3625 Howard St., Skokie, Ill.

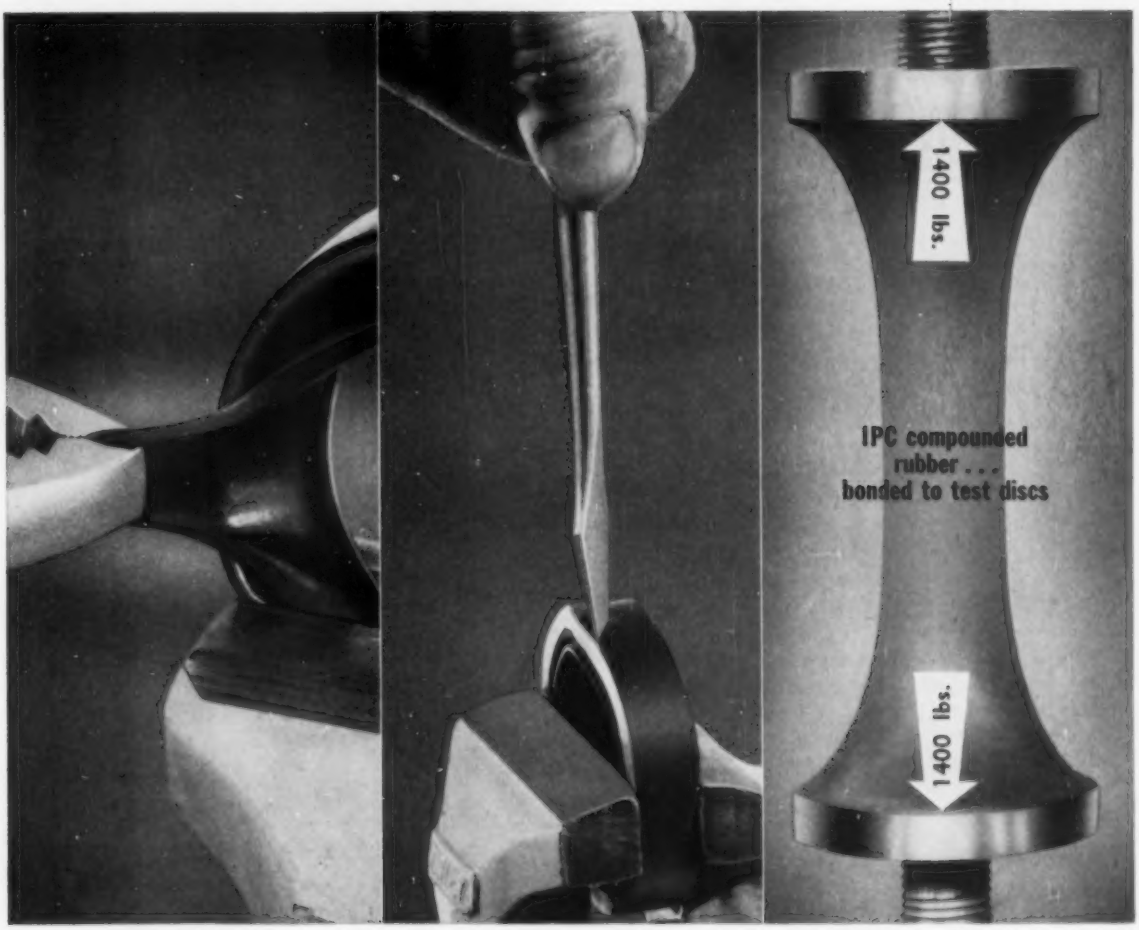
For more information—
Circle 50, inside back cover

Harmonic-Neutralized Voltage Regulator

These transformers are made in three capacities, 250, 500 and 1000 va. Regulation is ±1 per cent over a newly-expanded primary voltage range of 95 to 130 v. Sinusoidal output is delivered with less than 3 per cent harmonic distortion at rated load.

The constant voltage transformer

CONTINUED ON PAGE 236



TWIST IT . . . PRY IT . . . STRETCH IT

Bonded IPC Packings Stay Bonded

. . . Positive bonding — *rubber to metal*. More than a sticking process, the IPC bond is the result of a chemical affinity between these unlikely components. Here is a direct result of extensive laboratory testing.

IPC bonded case seals and bonded washer seals combine the steel parts, held to very fine tolerances, with special rubber compounds. Whatever your sealing requirement, IPC will help with your oil seal or packings design . . . solve your problem with better manufacture.

Custom design means low cost plus dependability. Call IPC first for oil seals, packings and precision molded products.

INTERNATIONAL PACKINGS CORPORATION

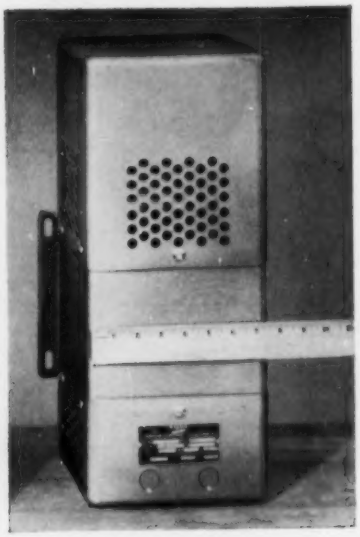
Bristol, New Hampshire

Branch Offices: Chicago, Dallas, Detroit, Kansas City, New York, Philadelphia, San Francisco, St. Louis.

BONDED BY IPC

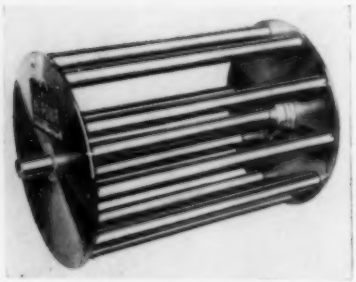
1. Bonded Washer Seal Double Lip Wiper
9. Bonded Case Seal Straight Lip With Garter Spring
2. Bonded Case Seal Double Lip Wiper
10. Bonded Case Seal Limited Contact Lip With Garter Spring
3. Bonded Washer Seal Straight Lip
11. Bonded Case Seal Straight Lip Thin Rind Type
4. Bonded Washer Seal Limited Contact Lip
12. Bonded Case Seal Limited Contact Lip Thin Rind Type
5. Bonded Washer Seal Straight Lip With Garter Spring
13. Rubber Covered Bonded Case Seal Straight Lip
6. Bonded Washer Seal Limited Contact Lip With Garter Spring
14. Rubber Covered Bonded Case Seal Limited Contact Lip
7. Bonded Case Seal Straight Lip
15. Rubber Covered Bonded Case Seal Straight Lip With Garter Spring
8. Bonded Case Seal Limited Contact Lip
16. Rubber Covered Bonded Case Seal Limited Contact Lip With Garter Spring

P4



may be used for the most exacting applications with equipment having elements which are sensitive to power frequencies harmonically related to the fundamental. It is especially suitable for input to a rectifier when close regulation of the dc output is required. Sola Electric Co., 4633 W. 16 St., Chicago 50, Ill.

For more information—
Circle 51, inside back cover



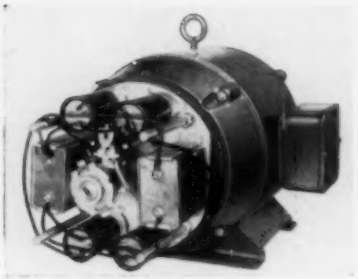
Rotating Grate Magnet

This permanent magnet cylindrical grate is designed for installation at the discharge end of open or enclosed chutes, or in open or closed duct systems. It will magnetically remove pieces of tramp iron or fine iron particles, while also minimizing clogging or bridging of material through the mechanical action of its rotation.

In operation, the grate revolves through the flow of material at a predetermined speed, related to the nature and condition of the material being processed. Under excessive choke conditions, for example, the Rota-Grate will deliver optimum magnetic separation at a slow 5 to 10 rpm. A top speed of 30 rpm should generally not be exceeded. For best results under average conditions, a speed of 15 to 20 rpm is recommended.

The separation is available in standard diameters of 12, 16 and 22 in., these being composed of 10, 15 and 20 magnetic tubes respectively, and in widths beginning at 4, 8 and 12 in., respectively and continuing, through 4 in. increments, to a maximum standard width of 36 in. for all diameters. Eriez Mfg. Co., Erie 6, Pa.

For more information—
Circle 52, inside back cover



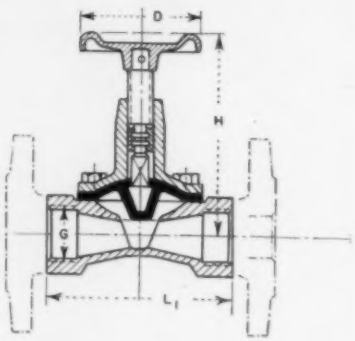
Motors Rated 10 and 15 Hp

Three motors, two rated at 10 hp and one at 15 hp, are of the capacitor single phase type, completely protected against weather, debris and small field animals. These drives are available in 1725 and 1140 rpm speeds. They are especially suited for use in the oil country, farm equipment manufacture and small industry, as well as on farms, in applications requiring more than 7½ hp on single-phase operation. Robbins and Myers, Inc., Springfield, Ohio.

For more information—
Circle 53, inside back cover

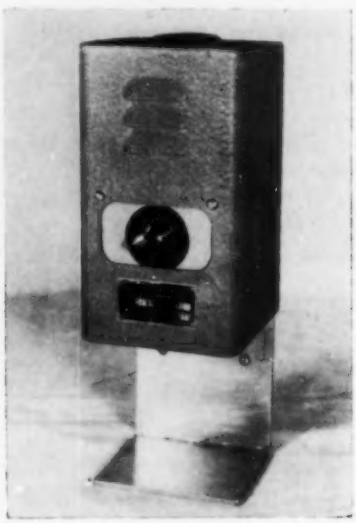
Diaphragm Slide Valve

This valve is shut off by a diaphragm which is moved in and out of position by a wedge. The diaphragm is double-ended, and is made of natural or synthetic rubber. Valve body is available



in cast iron, steel, brass or stainless. Valve is produced with inlet-outlet ports ranging from ⅜ to 2½ in. Hochdruck-Dichtungs-Fabrik, Schmitz und Schulte, Burscheid bei Koln, Germany.

For more information—
Circle 54, inside back cover



Electronic Timers

Two models are provided: the TA-1, which is enclosed in a housing suitable for mounting in the open, and the TA-2, a chassis model designed for use in conjunction with other electrical equipment. Both operate within the ranges of 0.05 to 1 sec, and 0.05 to 10 sec. The units operate without benefit of warmup, being operative as soon as power is applied. Voltage regulation is embodied in both units.

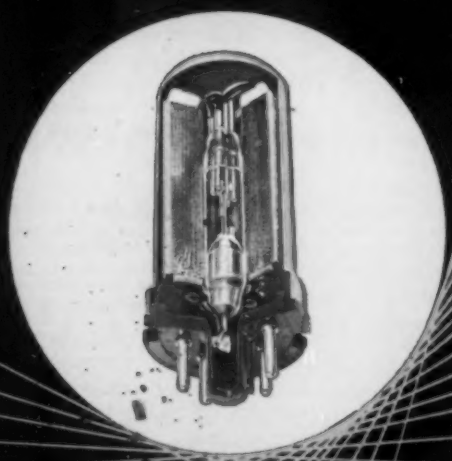
The time control adjustor, which is fitted with a scale (calibrated for 0 to 100), reads approximately in percent-

CONTINUED ON PAGE 238

It can cost you much more to settle for less than this Clare relay

This ad was all but written by a Clare customer. Here is the story as he told it:

"I shopped around for relays for continuous-duty, high-speed switching service. Clare engineers recommended Type HG Mercury-Wetted Contact Relays. They said they were ideal for this application. I thought so, too; but they do cost a little more than some other relays, and I thought I couldn't afford to use them. I thought the extra cost, multiplied by the large number of relays in my machine, would run my price too high. So I built a model with cheaper relays. In just a few weeks the relays wore out. I knew that Clare Type HG relays would last for years under the same conditions, and it didn't take me long then to decide that *I couldn't afford not to use them.*"



Ask yourself whether you, too, don't have jobs for which no other relay is good enough. Consider that the life of a Clare Mercury-Wetted Contact Relay is measured in billions of maintenance-free operations. Compare the cost per flawless operation with that of other relays: this is the crux of the matter—a vital, basic point.

The price is very reasonable, and delivery is quick—one to seven weeks, depending on the particular assembly desired and the size of the order.

FOR COMPLETE INFORMATION on CLARE Mercury-Wetted Contact Relays for single or multiple circuits contact your nearest CLARE representative or address: C. P. Clare & Co., 3101 Pratt Blvd., Chicago 45, Illinois. In Canada: C. P. Clare & Co., 659 Bayview Avenue, Toronto 17. Cable address: CLARELAY.

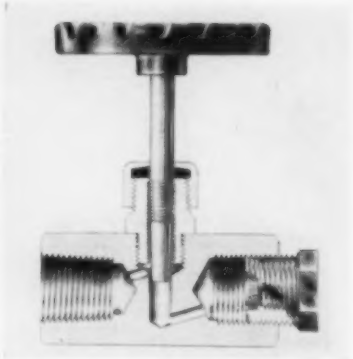
Send for CLARE Sales Engineering Bulletins Nos. 120 and 122

CLARE RELAYS

FIRST in the industrial field

age of the full range of the timer. Power supply required is 115 v, 60 cps. Overall dimensions: Model TA-1, 5¼x8¾x5¼ in. deep; Model TA-2, 5x 3¼x5 in. deep. Post Machinery Co., Beverly, Mass.

For more information—
Circle 55, inside back cover



Pulsation Dampener

A pulsation dampener provides adjustable control of fluctuations on pressure gages and controls. A porous metal filter-strainer prevents foreign particles from entering the valve body. Strainer is removable for cleaning. Frank W. Murphy, P.O. Box 1476, Tulsa 1, Okla.

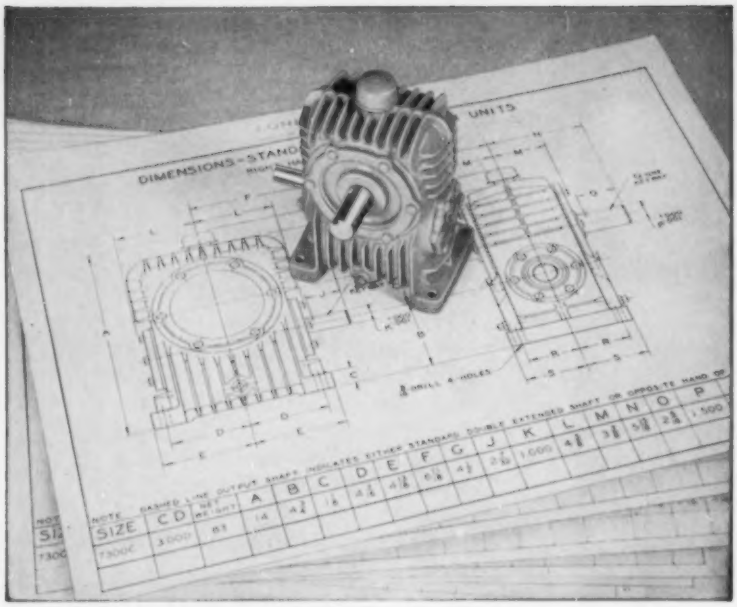
For more information—
Circle 56, inside back cover

Cadmium Sulfide Photoelectric Cells

Power sufficient to operate a relay at normal daylight levels is claimed for this line of photoelectric cells, which will control a commercial sensitive relay without amplification. These elements are said to be light sensitive over the entire visible spectrum, with a peak sensitivity to a blue-green color. They have a low noise level and high dark resistance; stability is rated excellent so long as power dissipation rating is not exceeded. Applications include illumination conveyor control, burgular alarms, door control, counting and smoke detecting.

These calls are divided into 11 sensitivity categories. Low impedance cells are intended primarily for direct relay operation, while high impedance cells are intended for use with an

(Continued on page 242)



DIMENSIONS ONLY TELL HALF THE STORY...

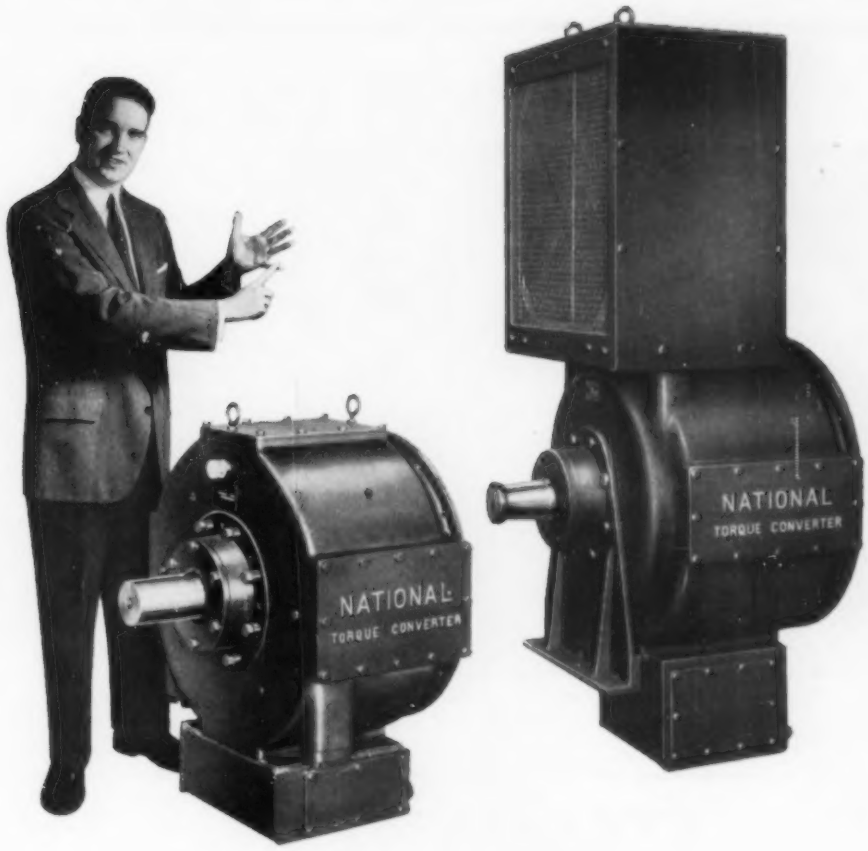
. . . about worm gear speed reducers. You've got to compare size with load capacity for the whole picture. Inside a Cone-Drive speed reducer you'll find the double-enveloping worm gear design that makes it the most efficient right-angle speed reducer available.

Take the standard 3" center distance unit above for example. Here are its Class I Service Ratings with a 5:1 reduction:

Worm RPM	100	200	300	580	720	870	1150	1750
Mech. HP	1.24	2.21	3.08	4.89	5.61	6.34	7.41	9.04
Thermal HP	1.24	2.21	3.08	4.20	4.62	5.10	6.00	7.80
Output Torque (inch-lbs.)	3340	3010	2830	2405	2250	2150	1940	1575

That's a lot of capacity for a unit that occupies less floor space than this magazine page. But it's typical of Cone-Drive speed reducers and gearsets. Complete details on this model in Bulletin 600-C. Other units to 800 HP and ratios to 4900:1.

CONE-DRIVE GEARS
Division Michigan Tool Company
DOUBLE ENVELOPING GEAR SETS & SPEED REDUCERS
7171 E. McNichols Road • Detroit 13, Michigan



you get all these features with a National Torque Converter

Now, with National Torque Converters, you can give your equipment smoother power, steadier power over a wider range of loads . . . with exact matching of torque converter to engines of 100 to 1000 horsepower . . . plus *all* these features:

Unsurpassed durability: The rugged design and construction of National Torque Converters provide longer service life with minimum maintenance.

Simplicity of design of National Torque Converters permits ease of installation, operation and maintenance.

Reproducible efficiency of each size and capacity of National Torque Converters permits standardization on your equipment with assurance of uniform top performance on every job.

Top performance: Precision fabrication of National Torque Converters of parts made to close tolerances provides uniformly smooth transmission of power hydraulically from engine to job or load, enabling engine to operate at its optimum speed and thus, to deliver maximum horsepower as required . . . and without ever stalling the engine.

Faster job cycles: Quicker starting and faster acceleration of load with a National Torque Converter in the power system means more work per equipment per operator per day . . . every day.

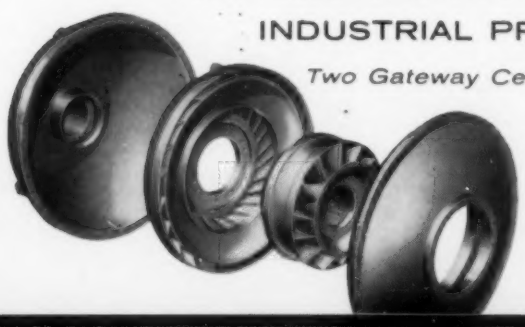
Full range of circuit sizes: You have a choice of 6 basic hydraulic circuit sizes, each with a range of input ratings, to permit exact matching of torque converter to specific power-speed characteristics of a prime mover.

Why not let a National engineer make specific recommendations of the correct size and capacity of National Torque Converter for your equipment.

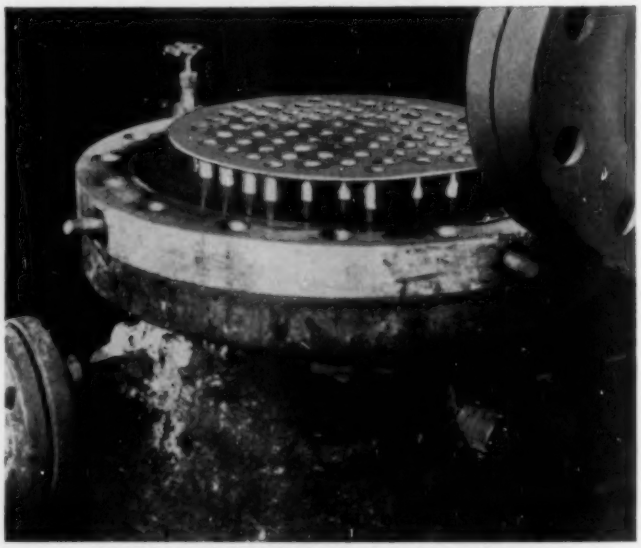
THE NATIONAL SUPPLY COMPANY

INDUSTRIAL PRODUCTS DIVISION

Two Gateway Center, Pittsburgh 22, Pa.



Pace-setters in the progress of industrial power transmission



'Top-hat' of REM-CRU titanium in service on condenser at E. I. duPont de Nemours, Inc.

Closeup of titanium 'top-hat'.

how **TITANIUM** 'top-hat' thwarts corrosion damage to DuPont condenser...

Problem: DuPont chemical engineers faced a particularly vexing problem in the frequent failure of a stainless steel condenser handling 60% nitric acid at 480F and 300 psi. Every five months or so, it became so badly corroded that replacement was necessary. Unit costs and downtime were serious.

Solution: Since failures always occurred at the condenser top, DuPont engineers decided to try protecting that area with a 'top-hat' insert of REM-CRU titanium. It consists of a titanium disc twelve inches in diameter, to which a cluster of 70 thin wall titanium tubes is welded. Fitting snugly into the top of the stainless steel condenser, the titanium protects the area where trouble started. *And it stopped failures completely.* The 'top-hatted' condenser has been in service for more than 16 months and still shows no sign of corrosion beyond a slight discoloration.

Dollars and Cents Facts About Titanium: It's true that titanium sheet and tubing cost more than stainless steel. But titanium's light weight (40% lighter than steel), means you must buy fewer pounds of *metal* for a given area. Furthermore, the cost of the metal is only a fraction of the cost of the finished assembly. Substituting titanium for stainless, therefore, increases the cost of a finished reactor, autoclave, valve or other piece of chemical equipment by only two or three times. Where titanium extends the service life of parts by such a factor, or eliminates costly maintenance and downtime, it's the obvious choice over cheaper but less corrosion-resistant metals.

At REM-CRU you can now get *prompt* delivery of this versatile metal in a wide variety of sizes, shapes and grades – including new high-strength, weldable alloys. REM-CRU engineers will be glad to help with selection, application or fabrication problems.

To keep abreast of the latest developments on this vital metal, write to Dept. P-7 for the Rem-Cru Review – a free periodical presenting the latest technical data on titanium alloys.

REM-CRU TITANIUM

REM-CRU TITANIUM, INC., MIDLAND, PENNSYLVANIA

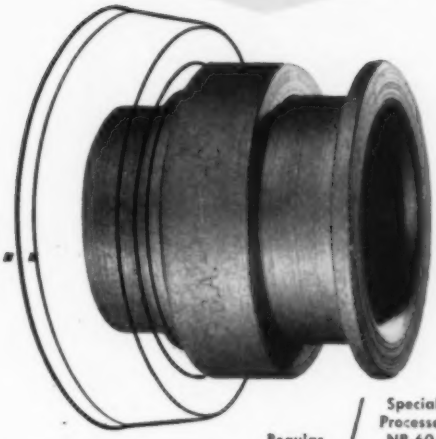
"SWITCH!" said Ostuco

. . . and savings were surprising!

Pleasant surprise, too! Bearings Company of America, Division of Federal-Mogul-Bower Bearings, Inc. Lancaster, Pa., was machining OSTUCO seamless tubing to make a clutch release bearing collar used as original and replacement equipment. Results were fine!

Then word came from OSTUCO, recommending a switch to OSTUCO's newly developed NP-60, tubing specially processed for machineability. Cost was slightly higher, but BCA and OSTUCO engineers predicted the savings would justify the change.

they switched . . .



and they SAVED!

	Regular	Specially Processed NP-60
Production per 8 hour shift (units)	675	840
Production time per 1000 units (hours) . . .	12.35	10.03
Total Labor per 1000 units (man-hours) . .	13.09	10.63

Besides the savings, Bearings Company of America was pleased with the better finish of the new part. They point out that the collar in photo above "shows the finish as it comes directly off the machine."

It happens this way often enough to warrant checking with OSTUCO about your tubing applications and production problems. Contact your nearest OSTUCO Sales Engineer or write direct to the Shelby factory —there's no obligation!

OSTUCO SHELBY OHIO

OSTUCO TUBING

SEAMLESS AND ELECTRIC RESISTANCE
WELDED STEEL TUBING—Fabricating and Forging

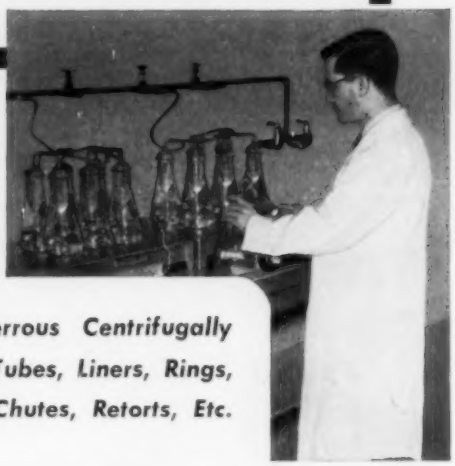
OHIO SEAMLESS TUBE DIVISION
of Copperweld Steel Company • **SHELBY, OHIO**
Birthplace of the Seamless Steel Tube Industry in America

SALES OFFICES: BIRMINGHAM • CHARLOTTE • CHICAGO (Oak Park) CLEVELAND • DAYTON • DENVER • DETROIT (Ferndale) HOUSTON • LOS ANGELES (Beverly Hills) • MOLINE NEW YORK • NORTH KANSAS CITY • PHILADELPHIA PITTSBURGH • RICHMOND • ROCHESTER • ST. LOUIS ST. PAUL • SALT LAKE CITY • SEATTLE • TULSA • WICHITA

CANADA, RAILWAY & POWER ENGR. CORP., LTD.

EXPORT: COPPERWELD STEEL INTERNATIONAL COMPANY
225 Broadway, New York 7, New York

To Rely on SANDUSKY Is to Rely on Research



CHIEF SANDUSKY

Ferrous and Non-Ferrous Centrifugally Cast Rolls, Sleeves, Tubes, Liners, Rings, Bushings, Bearings, Chutes, Retorts, Etc.

There's a great deal more to a centrifugal casting than the finished product itself. It starts in the early stages of development and planning when Chief Sandusky technicians, through research and test experience, are able to specify valuable procedures that will save production expense and man-hours in your operation.

Add to this research the right materials and consistent control and the result is a ferrous or non-ferrous casting which will do its specific job while resisting heat, abrasion, and corrosion as required. An additional service is machining facilities for turning, boring, and drilling.

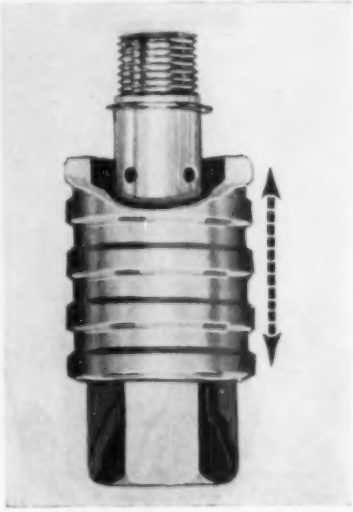
Rely on Chief Sandusky as an organization of specialists with the answers to your problems with the finest of centrifugal castings.

C. M. Lovsted & Co., Seattle, Wash. • Tynes Bros., Birmingham, Ala. • Cordes Bros., San Francisco and Wilmington, Calif.

Chief SANDUSKY CENTRIFUGAL CASTINGS
FERROUS AND NON-FERROUS
SANDUSKY FOUNDRY AND MACHINE CO., Sandusky, Ohio

amplifier. The sensitivities range between 20 and 1500 microamp (5 megohm down to 67,000 ohms). With proper amplification, these photocells will detect 0.001 ft-c. Hupp Electronics Co., 743 Circle Ave., Forest Park, Ill.

For more information—
Circle 57, inside back cover



Three-Way Sleeve Valve

Designed to control clamp-type and similar single-acting air cylinders, this valve has a sliding sleeve that actuates it. In downstream position, air flows through to the cylinder; in upstream position, inlet air is cut off and exhaust ports opened. An extension on the sleeve deflects exhaust air to protect operator from air blast, blown chips or dirt.

Available in $\frac{1}{8}$, $\frac{1}{4}$ and $\frac{3}{8}$ in. NPT sizes, the valve may be mounted directly in the cylinder port or at any convenient location in the airline. Inlet connection is female, outlet male. Valve body is machined from solid stainless steel; sleeve is all brass, with oil-resistant O-ring seals. Modernair Corp., 400 Preda St., San Leandro, Calif.

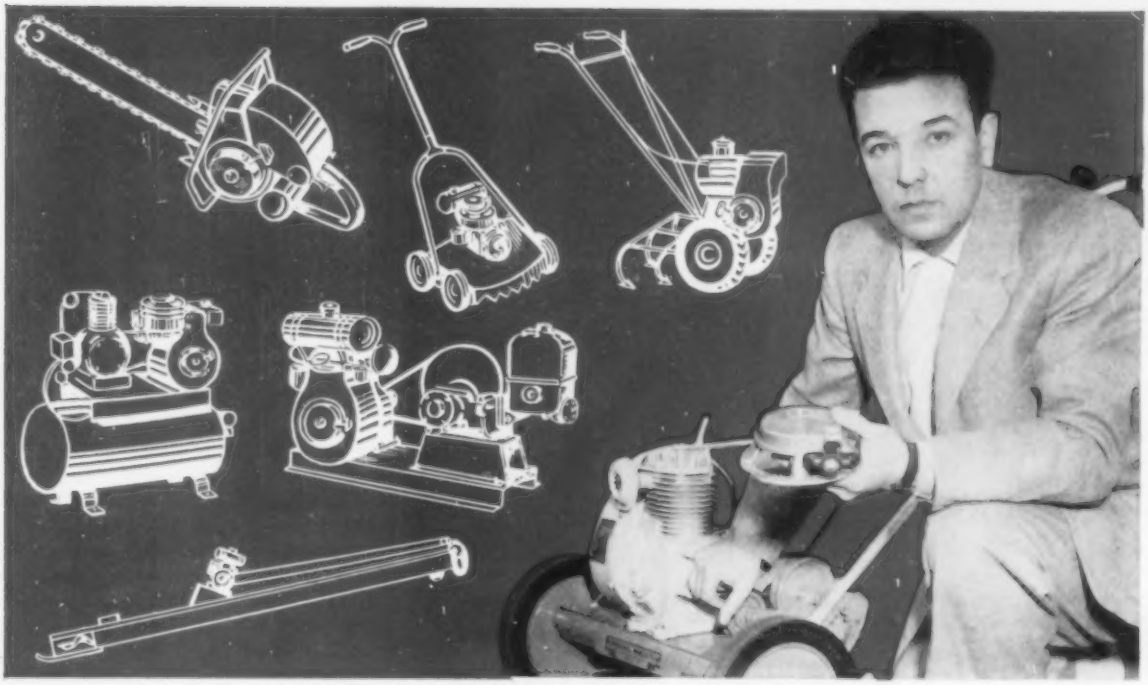
For more information—
Circle 58, inside back cover

Centrifugal Switch

Designed to detect a slow down or stoppage of any motor or piece of machinery, this switch gives a signal or actuates an electrical circuit to start

(Continued on page 244)

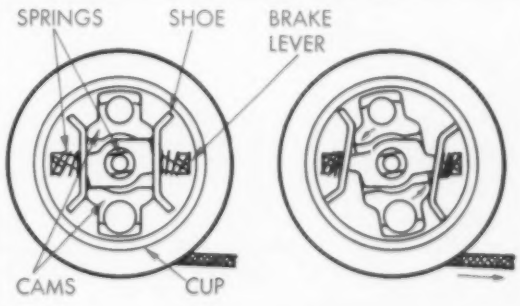
UPGRADE ENGINES AT LOW COST WITH FAIRBANKS-MORSE REWIND STARTERS



Here's why so many small-engine builders and users now make this easy addition

One of the best bargains in tangible, salable quality improvement you can add to the 1957 model of your small gasoline engine is a Fairbanks-Morse Rewind Starter. More thousands of Fairbanks-Morse starters are included by engine and equipment makers today than any other in this important field. The reasons are clear:

1. Only Fairbanks-Morse makes an automatic rewind starter for every existing rope-start engine. Any service shop can add it to your unit — you can add it without costly redesigning.
2. The biggest volume producer, Fairbanks-Morse, can give top quality at a better price.
3. Exclusive simplicity of design, top-quality materials . . . Properly used, Rewind Starter outlasts the engine to which it is applied.
4. Popular independently on the resale market, the Fairbanks-Morse Rewind Starter name teams with your own to increase salability. Let Fairbanks-Morse national advertising work for you.
5. Exclusive design makes the Rewind Starter equally convenient mounted in any position on your engine — no redesign needed.
6. A large network of Rewind Starter sales and service outlets assure ample service.



HOW IT WORKS

Starts quickly — When rotor assembly is rotated, cam-actuated special alloy shoes are forced outward until they grip the inner wall of the cup. Shoes are engaged after only ¼ in. pull of the cord. Spring-loaded, the shoes disengage instantly when pull stops.

Simple design — There's nothing to go wrong or wear out. Shock-free operation extends service life, usually longer than life of the engine on which starter is used.

FREE TEST UNIT. Make us prove we have in production a high-quality Rewind Starter for easy application to your engine. Write us today on your letterhead, stating type, make, and model. No charge or obligation, of course.

FAIRBANKS-MORSE

A name worth remembering when you want the BEST

MAGNETOS • REWIND STARTERS • WATER SYSTEMS • GENERATING SETS
PUMPS • MOTORS • SCALES • DIESEL LOCOMOTIVES AND ENGINES

"FAIRFIELD for FINE GEARS"

WHAT **FAIRFIELD**

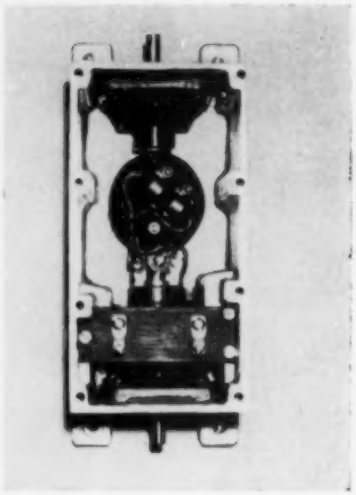
Experience MEANS TO YOU

Experience is the "plus value" that goes into every Fairfield gear *at no extra cost.* It is your assurance of dependable gear performance combined with the utmost in production economy. By specializing exclusively in "Fine Gears Made to Order" for more than thirty-five years, Fairfield has become one of America's largest independent producers of these parts. This is why many makers of Construction Machinery . . . Agricultural Implements . . . Machine Tools . . . Material Handling Equipment . . . Trucks, Tractors, and Buses now regularly depend on Fairfield to meet their requirements.

Fairfield's facilities are unexcelled. Here, in a new and ultra-modern plant you will find a complete metallurgical department, batteries of the most modern machines, testing laboratories, latest heat treating equipment—all operated by skilled craftsmen working under expert engineering supervision. *For the Best in Gears, Specify Fairfield!*

FAIRFIELD
MANUFACTURING CO.

2305 S. Concord Rd. — For FINE GEARS — Lafayette, Indiana



or stop allied or feeding machinery. Conditions such as clogging, slipping belts, broken shear-pins or drive chains, or simple power interruptions are typical of possible actuating causes.

This model will accept any voltage from 6 to 600 v, ac or dc and operate at any speed up to 3400 rpm. Functioning of this switch is accomplished by means of a metal-clad mercury tube mounted on an adjustable disc, and with an opposing off-center metal slug serving as a counterpart to remove any vibration due to the variable position of the mercury pool. Spinning on a sealed ball bearing, the collector rings complete the controlling factor. Ralph C. Gardner & Co., Lima Road, Fort Wayne 8, Ind.

For more information—
Circle 59, inside back cover

Panel-Mounted A-c Meters

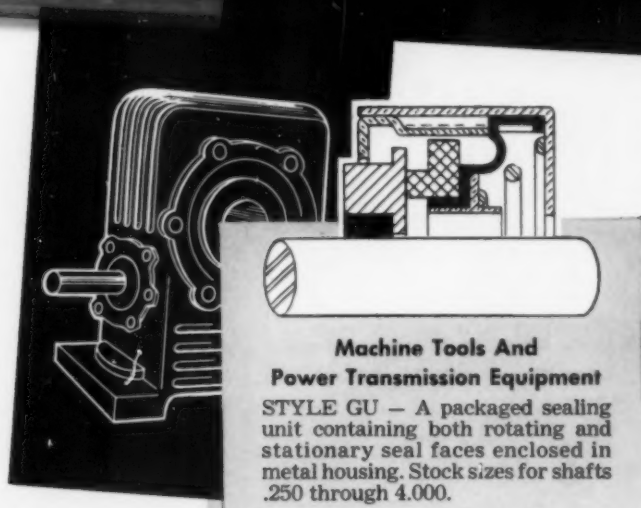
This meter is said to provide a standard accuracy rating of ±5 percent. The manufacturer also claims that the radical change of design provides a meter that will withstand an overload of 300 percent. Sterling Mfg. Co., 7199 Wentworth Ave., Cleveland, Ohio.

For more information—
Circle 60, inside back cover

Hermetically Sealed Displacement Transducer

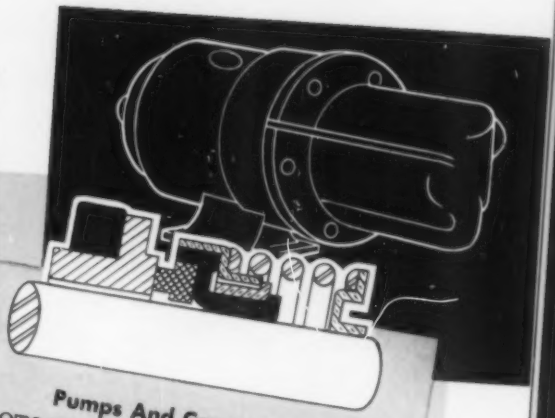
A new submersible type of variable permeance linear transducer will operate completely submerged in liquid

(Continued on page 247)



Machine Tools And Power Transmission Equipment

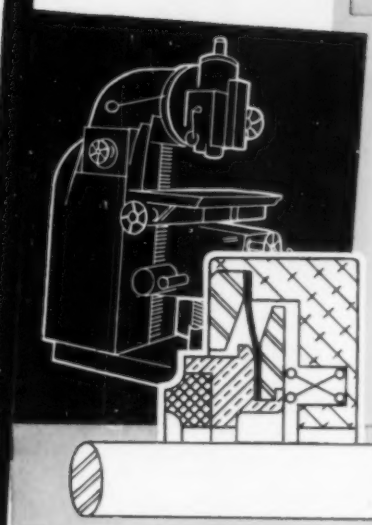
STYLE GU — A packaged sealing unit containing both rotating and stationary seal faces enclosed in metal housing. Stock sizes for shafts .250 through 4.000.



Pumps And Compressors

ROTO-FLEX — Rugged flexibility. Only 3 parts. Single or double units. Stock sizes for shafts .250 through 4.000.

STYLE RFO — A specially designed Roto-flex seal, for installation outside the stuffing box. Stock sizes for shafts .250 through 4.000.



Heavy Machine Tools

STYLE DPC — A high-speed, carbon-faced seal, for more compact installation in heavy industrial machinery. Stock sizes for shafts .250 through 4.000.

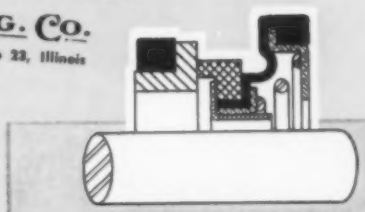
A Complete Line
GITS SHAFT SEALS
For Every Application

These modern, mechanical, face-type seals are carried in stock — to save you time and money. Write for detailed data.

GITS BROS. MFG. CO.

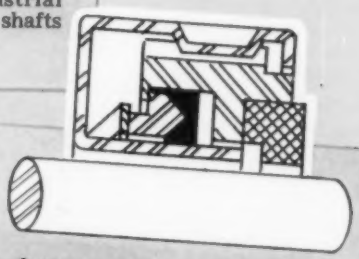
1838B South Kilbourn Avenue • Chicago 23, Illinois

Specialists In Lubricating Devices And Shaft Seals For Almost Half-A-Century



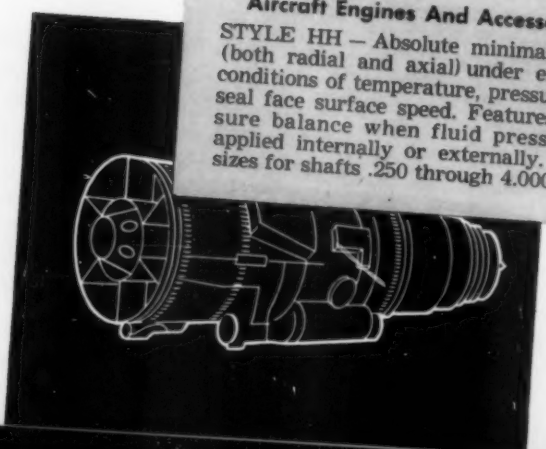
Household Appliances

STYLE SGU—A factory-assembled unit-type seal for the small-budget user. Stock sizes for shafts .250 through 1.000.



Aircraft Engines And Accessories

STYLE HH — Absolute minimal space (both radial and axial) under extreme conditions of temperature, pressure and seal face surface speed. Features pressure balance when fluid pressure is applied internally or externally. Stock sizes for shafts .250 through 4.000.



Guarantee TOP Performance and Maximum Life!

Specify THESE TOP QUALITY FEATURES...

(Standard on Miller Cylinders at no extra cost)

Specify CASE HARDENED CHROME PLATED PISTON RODS

On all Air and Hydraulic Cylinders

Benefits To You

CASE-HARDENED Piston Rods (52-54 Rockwell "C") provide practically complete protection against damage from hammer blows, wrench-dropping, mishandling, and similar occurrences. ***Available from Miller at no extra cost.***

The HARD CHROME PLATING over the case-hardened rods protects against scratch-damage and rust. ***Available from Miller at no extra cost.***

Specify "TEFLON" WIPERS

On all Air and Hydraulic Cylinders

Benefits To You

"TEFLON" Rod Wipers and "TEFLON" Hydraulic Piston Rod Seals withstand temperatures from—100°F. to plus 500°F. They are impervious to practically all known chemicals, including the fire-resistant, special, and standard hydraulic fluids in current use. ***Available from Miller at no extra cost.***

Specify TEFLON HYDRAULIC ROD SEALS

On all Hydraulic Cylinders

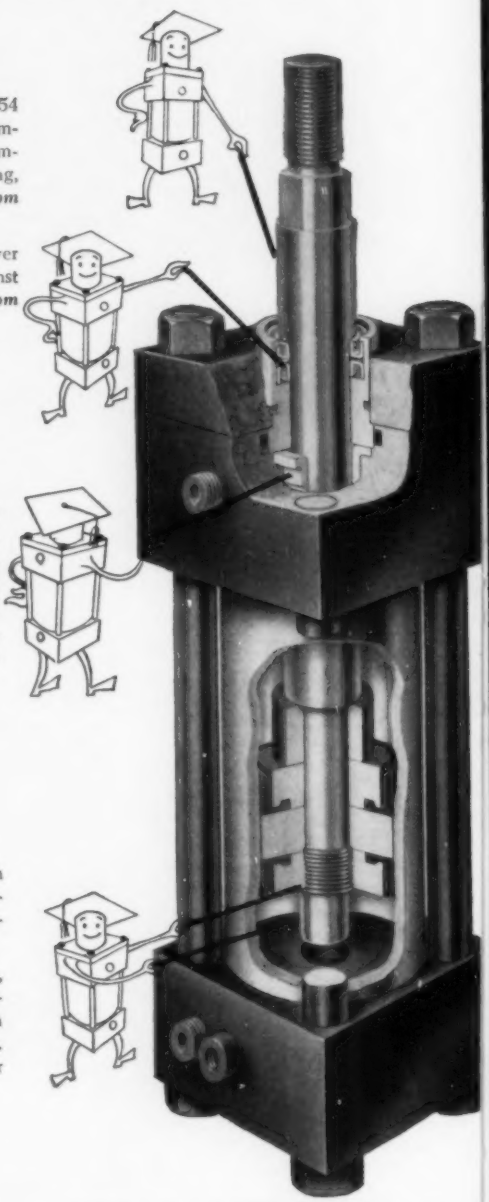
Specify RUST RESISTANT SURFACES

On all Air and Hydraulic Cylinders

Benefits To You

Highest quality Black Ferric Oxide Finish provides rust protection in air cylinder operation and on all cylinders during shipping and installation.

Cylinder heads, caps, mountings, pistons, followers, tie rods, and the unplated portions of the piston rods have this finish ***at no extra cost on all Miller cylinders.*** (This finish not recommended for water service)



NOTE. On all Miller Hydraulic Piston Seals: Leather Cup Seals are *standard*, Piston Ring Seals are optional at *no extra cost*, and "Teflon" Cup Seals are available *at extra cost.*

You may wish to route this entire page to the proper department in your company, by using this handy form. Additional copies on request. →

To (Dept.)_____

"On all our future cylinder requirements, please specify the above quality features."

Signed_____

Title_____

Member of the National Fluid Power Association

SALES AND SERVICE FROM COAST TO COAST

CLEVELAND • YOUNGSTOWN • DAYTON • TOLEDO • CINCINNATI • COLUMBUS
PITTSBURGH • PHILADELPHIA • BOSTON • HARTFORD • NEW YORK CITY
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TORONTO, CANADA and OTHER AREAS

Miller

MILLER FLUID POWER DIVISION
FLICK-REEDY CO

2002-04 N. Hawthorne Ave. Melrose Park, Ill.

AIR & HYDRAULIC CYLINDERS • BOOSTERS • ACCUMULAT
COUNTERBALANCE CYLINDERS

under pressure. It is designed to sense linear motion, position, displacement or vibration. The pickup housing is an all-welded assembly, and the connecting leads are conducted out of the immersion area through tubing which attaches to an AN fitting welded to the housing.

All material exposed to the liquid is stainless steel. Linear ranges from 0.2 to 164 in. are available. Various models will work in ambient temperatures from −160 F to 1300 F. Crescent Engineering & Research Co., 11632 McBean St., El Monte, Calif.

For more information—
Circle 61, inside back cover

Miniature Cooling Fan

The motor is of the inside-out construction, whereby the electrical rotor and the air moving impeller are integrally cast in one piece. This fan moves 58 cfm at free delivery and 35 cfm at 2 in. static pressure. It is 2x1½ in. long and weighs 4 oz. The unit runs at 20,000 rpm and is wound

(Continued on page 250)

STOP PIPE THREAD LEAKS with

PAT. PENDING

Does away with messy pipe "dope" compounds!

. . . Eliminates valve and pump damage caused by overtightening of leaky joints.

. . . "TEFLON" SEAL is immune to ALL hydraulic fluids and to steam, air, water, solvents and practically all gases and chemicals!

. . . Withstands temperatures from —100° F. to plus 500° F.!

. . . Fully field tested and proven by leading manufacturers!

EASY INSTALLATION!

1 Thread TRU-O-SEAL on pipe or fitting (no messy pipe "dope" needed).

2 Thread pipe or fitting 4 threads into port. Point in desired direction.

3 Tighten TRU-O-SEAL to complete leakproof assembly (only light torque required).

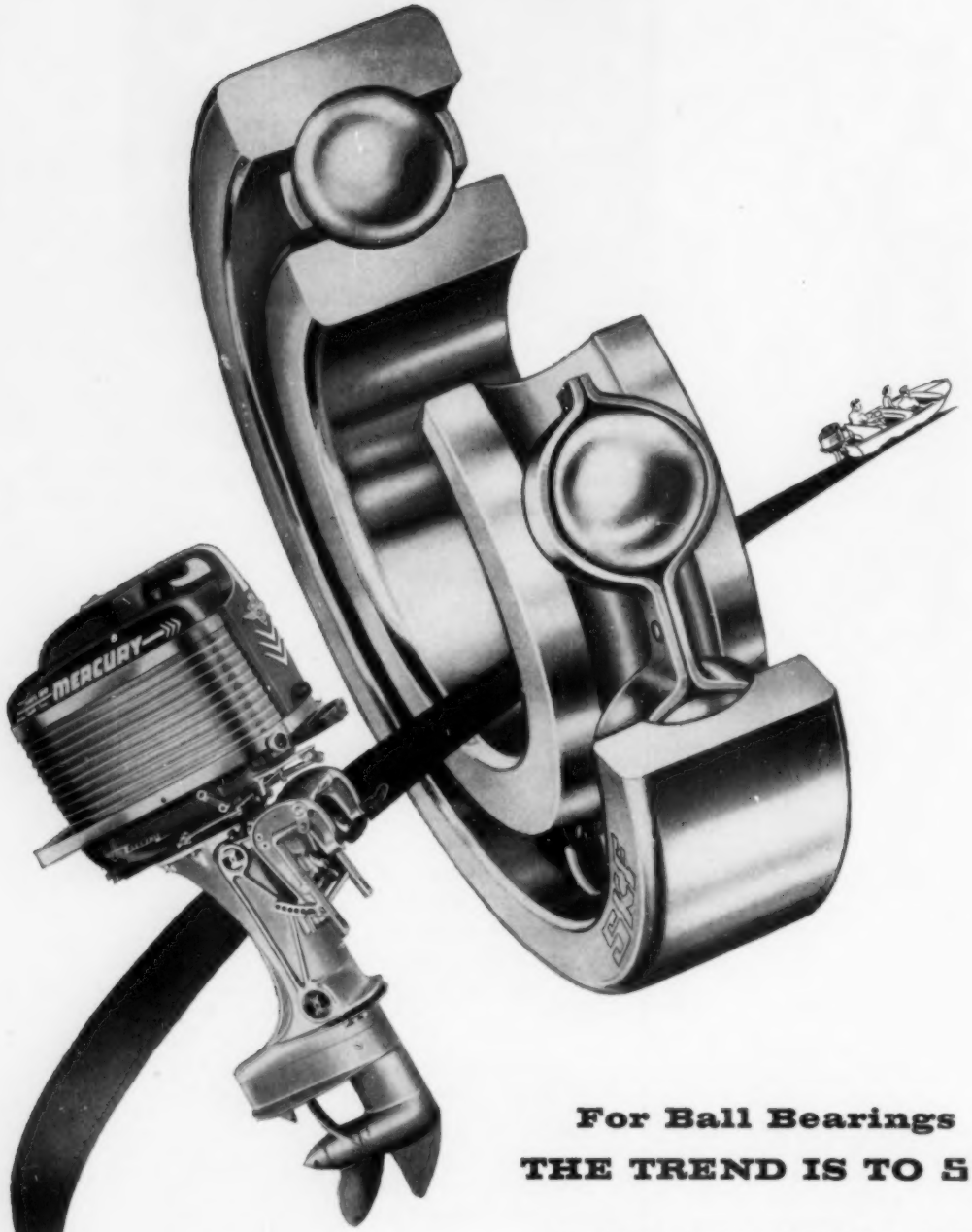
TRU-O-SEAL stops present pipe thread leaks instantly, prevents future leaks, saves cost and labor of special or welded fittings. For 3000 psi operation (15,000 psi minimum proof pressure). Comes in ⅛" to 2½" pipe thread sizes.

Write for Prices and Complete Data

TRU-O-SEAL DIVISION
Flick Reedy Corporation

2002-04 N. Hawthorne Ave. Melrose Park, Ill.

"Miller Fluid Power" is also a division of Flick-Reedy Corp.



For Ball Bearings
THE TREND IS TO SKF®

Sleek, slim, powerful, quiet... *Mercury Outboards* are the ruler of speed and spray – "Master of the Waterways." Kiekhaefer Corporation, who makes them, was first to feature extensive use of anti-friction bearings in outboards. And Kiekhaefer is another concern that purchases single row, deep groove ball bearings from SKF.

It's a trend... brought about because those whose business is to buy bearings recognize the improvements SKF has achieved in ball bearings – improvements in quiet running, improvements in sealing, improvements in bearing life. Maybe *you* too should switch to SKF Ball Bearings.

SKF INDUSTRIES, INC., PHILADELPHIA 32, PA.

7709

SKF
has them all

Ball Bearings ◯ Cylindrical Roller Bearings ▭
Spherical Roller Bearings ▭ Tyson Tapered Roller Bearings ▭

Solder Rings

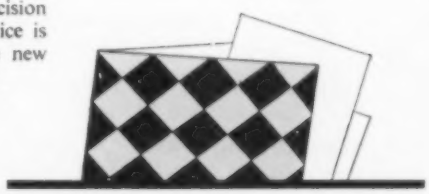
-in any size...and any quantity

NEW from Sylvania's 4-way parts service

Now, Sylvania's 4-way parts service is ready to offer you solder rings in any size and any quantity to meet all your production needs.

New techniques, developed by Sylvania, introduce new economies and throw an entirely new light on preformed solder price and delivery. Solder rings is just one of the many services offered by Sylvania's Parts Division.

Four-slides, and special Sylvania-designed equipment can meet all your needs in wire and ribbon forms and precision small parts. Complete design service is also provided and can introduce new economies into parts procurement.



Metal Stampings is an important part of Sylvania's 4-way service to designers. For the complete story, write for the "Portfolio of 4-Way Service to Designers." Address Dept. G33S.

PARTS DIVISION

metal stamping | special wire | molded plastic | electronic parts

SYLVANIA®

SYLVANIA ELECTRIC PRODUCTS INC.
1740 Broadway, New York 19, N.Y.
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LIGHTING • RADIO • TELEVISION • ELECTRONICS • ATOMIC ENERGY

NEW

2300 Series HAYDON* Timing Motor

Packed with PREMIUM Power and Performance!

Here is a new, more powerful timing motor with the extra torque and gear train stamina you need for today's appliance timers and dozens of other timing jobs. And this bonus in power is combined with the usual HAYDON hysterisis motor advantages; small size, quiet operation, dependability, total enclosure and all-position synchronous operation.

Speeds — 1, 2, 4, 6, 8 and 10 rpm; torque -10 ounce-inches at 1 rpm; 115 and 230 volt, 60 cycle.

HAYDON MOTORS — *A product of sound engineering and precision manufacturing . . . highest quality always. Write today for engineering data sheets on this new 2300 Series Motor . . . and for catalogs describing the complete line of HAYDON Timing Motors and Devices. Or contact the HAYDON Field Engineer nearest you.*

* Trademark Reg. U.S. Patent Office

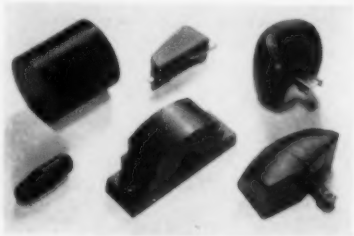
HAYDON AT TORRINGTON
HEADQUARTERS FOR TIMING

A SUBSIDIARY OF GENERAL TIME CORPORATION

HAYDON Manufacturing Company, Inc.
3131 ELM STREET, TORRINGTON, CONN.

for 400 cps only, either 200 v, three phase or 115 v, single phase. Both types have an input of only 35 w. The fan is fitted with solder-type hermetic terminals rather than leadwire, which allows the unit to be inserted in an airtight piping system. Rotron Mfg. Co., Schoonmaker Lane, Woodstock, N. Y.

For more information—
Circle 62, inside back cover



Unicellular Rubber Floats

Floats of hard unicellular rubber sponge, fabricated to customer specification, are said to be lighter than cork, to withstand higher temperatures, to be resistant to fungus growth, to need no protective coating, and to maintain stable weight and volume. It can be drilled or otherwise machined and can be molded to shape with or without metal mounting arm. It has a specific gravity of 0.14. The material is suitable for use in water, oil, gasoline, aviation fuels and various other liquids, over a wide temperature range. Parker Appliance Co., 17325 Euclid Ave., Cleveland 12, Ohio.

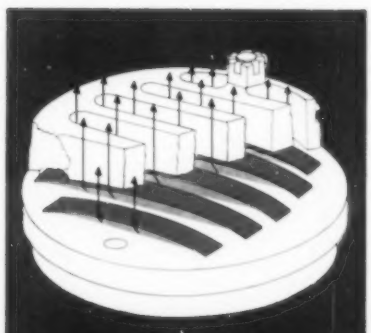
For more information—
Circle 63, inside back cover

Miniature Oil-Hydraulic Pump

A series of miniaturized oil-hydraulic pumps was designed, with unusually high power/weight ratios and limited life, for use in missile hydraulic

(Continued on page 253)

This compressor valve works with no impact for longer life, best efficiency



Stainless steel strips, in red, open the Feather Valve ports by rolling contact against the lower plate. There is no impact.

The Feather* Valve is the lightest, simplest, quietest compressor valve ever developed. Flexible strips of stainless steel open and close the valve ports with a gentle rolling contact. There is no destructive impact . . . even when the valve is operating as fast as forty times a second.

This lack of impact assures long life and negligible maintenance. The valve itself is all but indestructible. Absence of buffer plates and cushioning devices give it extreme simplicity.

The Feather Valve is quiet and reliable because of its lightness and tight contact seating. Valve action is very sharp. There is virtually no slip or back flow. As a result, you get minimum valve loss and use minimum power.

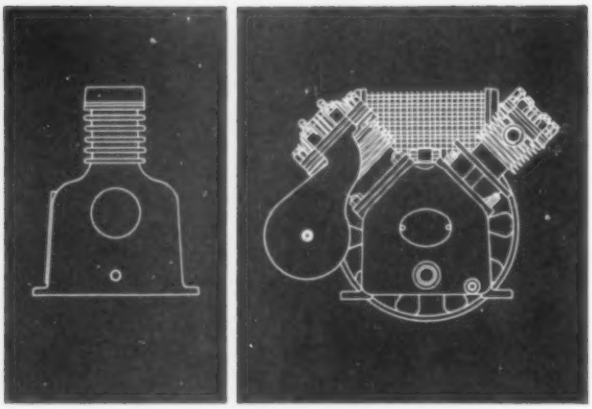
To get the utmost in performance, be sure you specify Worthington when you buy your next compressor. Worthington Corporation, Harrison, N. J. K.6.2

WORTHINGTON

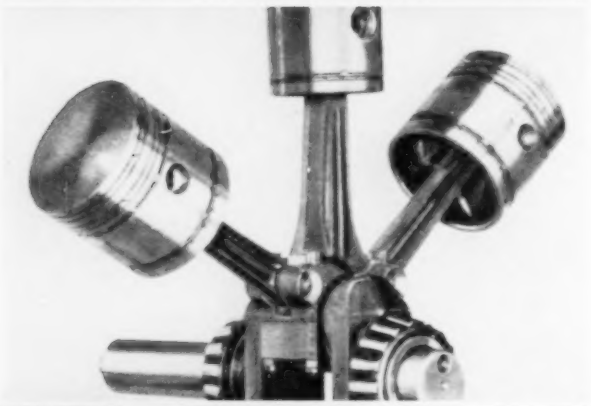
*Reg. U. S. Pat. Off.

WHAT'S YOUR C.Q.?*

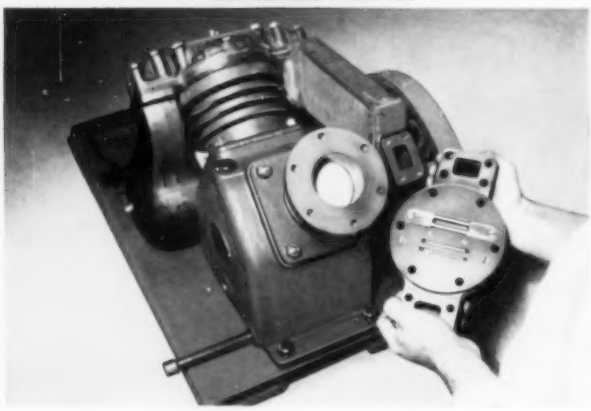
*COMPRESSOR QUOTIENT



In-line or V-type—which is more efficient? In certain fields, this is a hotly debated subject. In compressors, however, most authorities agree that the V-type design provides better balance, smoother running, and better cooling. Besides building only the more efficient V-type design, Worthington casts each cylinder separately from the crankcase. Air thus flows completely around the isolated cylinders, increasing efficiency and saving power dollars.



Why is this connecting rod "aerodynamically" sound? This articulated connecting rod design assures smooth effortless operation, less bearing wear and longer life. It's used in all Worthington radial compressors because it lowers crankpin bearing pressure. One large bearing carries peak connecting rod loads which occur at successive intervals. It's aerodynamically sound because the design is also used in all modern radial aircraft engines.



What important maintenance feature is he demonstrating? When a compressor is operating, valves open and close as many as thirty-three times a second. Valve maintenance is therefore of major concern to all users. Unlike many other makes which require replacement of the complete cylinder or head, all Worthington compressors are equipped with individually replaceable valves and valve guard seats. This is just one of the many Worthington features which save you time and money.

PC. 6.4

To increase your C. Q., write today for the complete story on Worthington's line of standard compressors. Ask for bulletins H-630-B1 and H-605-B3C. Address Section PC64, Worthington Corporation, Harrison, N. J. In Canada: Worthington (Canada) 1955, Ltd., Toronto, Ont.

WORTHINGTON

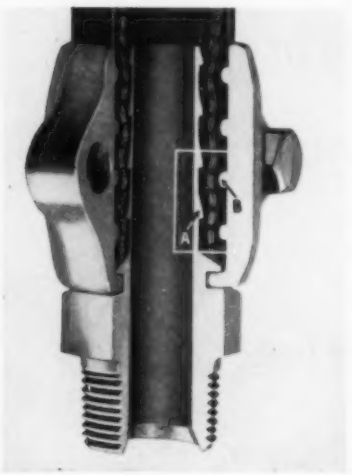
SPECIFY THESE WORTHINGTON STANDARD PRODUCTS ON YOUR EQUIPMENT

Air Compressors • Pumps • Multi-V-Drives • Allspeed Drives

systems and motorpump assembly installations for supplying emergency power on aircraft. Under conditions of optimum system operating pressure and maximum design speed, certain models are capable of developing more than 6 hp per lb of total weight.

Pump life and performance is consistent for inlet oil temperature conditions up to 200 F. Pumps having strokes up to 15 deg are available. Model 3906 is 2½x1⅝ in. dia, and weighs less than 1 lb. Vickers Inc., Box 302, Detroit 32, Mich.

For more information—
Circle 64, inside back cover



Clamp Coupling for Hose

Positive positioning is obtained as the outside rib of the clamp is locked between the collar and hex of the insert, before tightening. The device is for low, medium and high pressure hose up to 5000 psi working pressure. Clamps available for hose sizes ranging from ¼ to 2 in. ID, according to pressure requirements. Three standard in-

(Continued on page 256)

there's an amazing
CONCENTRATION OF HEAT
in this tiny cartridge unit!
the new WATLOW
FIREROD
cartridge heaters

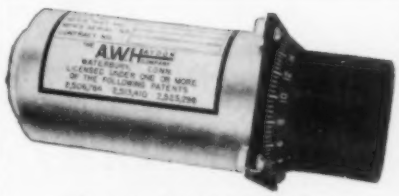
ACTUAL SIZE
(⅞" long, ⅜" dia.)
Rating: 115 V. —125 W.

A new design advantage for you. As *much heat* in 1/5th the space. Standard Units from 1¼" to 12" long, ⅜" and ½" dia.

Example of Application
Used to heat metal die to 900°F. forming titanium in the Aircraft Industry.

WRITE . . . for Illustrated Bulletin.

WATLOW
SINCE 1922—DESIGNERS AND MANUFACTURERS OF ELECTRIC HEATING UNITS
ELECTRIC MFG. CO.
1392 FERGUSON AVE.
SAINT LOUIS 14, MO.



precision components pay off in performance

THE A. W. HAYDON CO. SPECIAL TIME DELAY RELAY never gives in to severe vibration, shock or sustained acceleration. Positive detent arrangement maintains time setting under all conditions. Large adjusting knob facilitates changing of time setting. Stepless clutch drive minimizes clutch error.

SPECIFICATIONS

1.* Voltage Range: 24-29 Volts DC at 68°F.

2. Accuracy over Calibrated Range of adjustment:
(a) ±0.1 second or ±1% of setting, under condition 1.*
(b) ±0.15 second or ±2% of setting, over wide temperature range.

3. Meet Military Specs. for temperature, altitude, sand and dust, fungus, salt spray, radio filtering.

4. Vibration: 5-55CPS with total excursion 0.060".

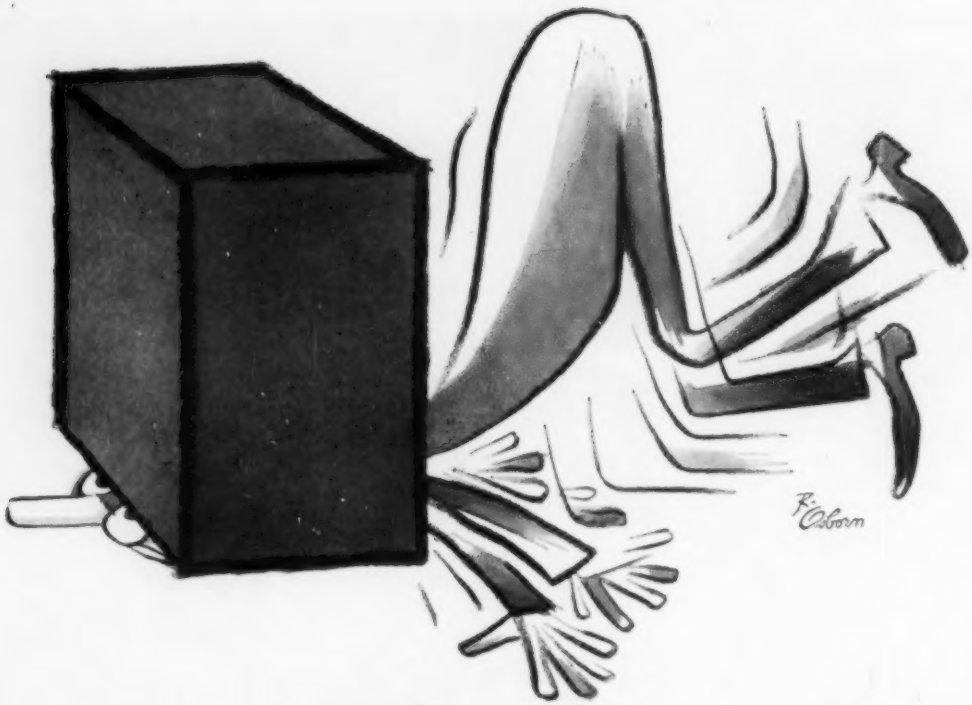
Current ratings at 29 Volts and room temperature:

1. Motor— 25 Milliamps
2. Clutch— 200 Milliamps
3. Contacts— 1.0 Amp inductive

Time delay period can be adjusted in 2/10 second increments over range of 0.2—30 seconds. (Catalog on Request)

PREFERRED WHERE PERFORMANCE IS PARAMOUNT

The A.W.HAYDON Company
Design and Manufacture of Electro-Mechanical Timing Devices
221 NORTH ELM STREET
WATERBURY 20, CONNECTICUT



Got a LOAD on Your mind?

Burdened down with a problem in design diminution, weight reduction, power capsulation? Lighten the load on your mind—send for the amazing story on how MPB's* such as these

BALL BEARINGS ACTUAL SIZE

make designing a breeze.

*MINIATURE PRECISION BEARINGS, INC.

4 Precision Park, Keene, New Hampshire

AMP

DYNAcrimp TOOL

for reliability plus versatility

An electrically-controlled pneumatic-hydraulic tool combining the convenience of a hand tool and the power of a bench press . . . Mounted on a portable cart which serves as a support . . . Power unit and tool may be detached for use in hard-to-reach locations . . . Operated either by foot pedal or thumb contact button . . . Adapted for use on A-MP Solistrand, Ampli-Bond and Aluminum terminals.

ask about
amp's Creative Approach
TO BETTER WIRING

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A-MP—Holland N.V., 's-Hertogenbosch, Holland • Aircraft-Marine Products (G.B.) Ltd., London, England

NEW GEROTOR PUMP-MOTOR

The new Gerotor MB-PMB1.5 Pump-Motor opens wider horizons to the hydraulic designer. Usable as either a pump or a motor, this compact power-package delivers a combination of features previously not found in standard designs.

- 2000 P.S.I.—5000 R.P.M.
- 115% Starting Torque
- 10—1 Speed Range, at
- Constant Torque
- Reversability
- Up to 3.4 H.P.
- High Efficiency, at
- Low Operating Cost.

Consult your nearest Gerotor distributor. Free literature available . . . *write:*

Progress Through Fluid Power by—

GEROTOR

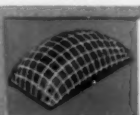
MAY CORPORATION

MANUFACTURERS OF—

1511 MARYLAND AVENUE, BALTIMORE 3, MARYLAND

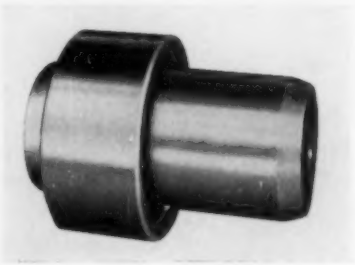
Hydraulic Pumps and Motors

Variable Speed Hydraulic Transmissions


PneuBin—Pneumatic Bin Evacuators

serts: male pipe, male flare and swivel female. Malleable iron clamp is furnished with heat treated bolts. Eastman Mfg. Co., Manitowoc, Wis.

For more information—
Circle 65, inside back cover

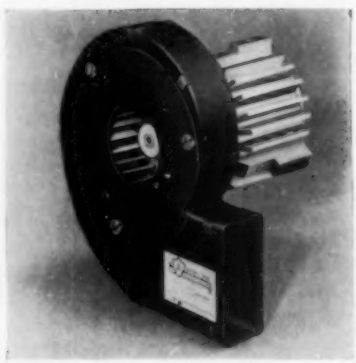


Flexible Gear Coupling

A type of gear coupling accommodating mill motors with tapered shafts has a sleeve and one hub of standard design. The other hub is taper-bored to specification and a space provided for a nut on the end of the motor shaft. Horsepower capacity is said to be greater than that of conventional flange-and-bolt types.

Mill motor flexible gear couplings are available in stock sizes $\frac{7}{8}$ to 6 in. with capacities ranging from 4 to 600 hp per 100 rpm. Sier-Bath Gear and Pump Co., Inc., 9249 Hudson Blvd., N. Bergen, N. J.

For more information—
Circle 66, inside back cover



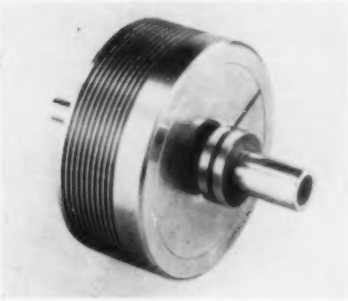
Centrifugal Blower

The blower has maximum dimensions of $3\frac{7}{8}$ x $4\frac{3}{8}$ in. It can be furnished with motors built to applicable government specifications operating from 115 v, single or three-phase, 60 or 400 cps 24 v, dc. Typical air deliv-

(Continued on page 257)

ery is 60 cfm, when driven by a four-pole motor at 11,000 rpm. American Electronics, Inc., 655 W. Washington Blvd., Los Angeles 15, Calif.

For more information—
Circle 67, inside back cover



Hysteresis Clutch

A hysteresis clutch for maximum torque with a minimum amount of control power is used in applications requiring proportional torque control. Torque generated in the hysteresis clutch is 140 in.-oz, with input power of 65 milliamp at 78 v, dc. The coil resistance at 25 deg is 1200 ohm. Overall dimensions are approximately 3⅜x4½ in. length. American Electronics, Inc., 655 W. Washington Blvd., Los Angeles 15, Calif.

For more information—
Circle 68, inside back cover

Motor Speed Control

Through multiple-feedback design, this magnetic amplifier control unit measures operating speed of a motor by sensing its armature current and voltage drop. It applies an instantaneous correction voltage whenever load conditions or other causes threaten a speed change. Motor speed can be preset by means of a conventional 2 w rheostat, remotely located if desired.

(Continued on page 258)

Our customer* needed a variable speed device to power a conveyor "assembly and test stand" which would accommodate metal conveyors up to 18 feet in width and up to 100 feet long. The Gerotor Variable Speed Hydraulic Transmission was the drive selected because it has a:

1. *wide enough speed range*
2. *smooth enough power flow*
3. *built-in overload protection*
4. *compact size, and*
5. *low maintenance factor.*

The installation engineered by Gerotor allows the operator to run the conveyor at speeds *from a smooth creep condition of 6 inches per minute to 120 feet per minute.* The added versatility of being able to adjust the torque output at any speed was theirs at NO EXTRA COST, and the conveyor can be stopped or reversed by means of the Gerotor Transmission.

If you have a hydraulic transmission problem . . . bring it to Gerotor. Free literature available . . . *write:*

*name on request.

Progress Through Fluid Power by—

GEROTOR
MAY CORPORATION

MANUFACTURERS OF—

1511 MARYLAND AVENUE, BALTIMORE 3, MARYLAND

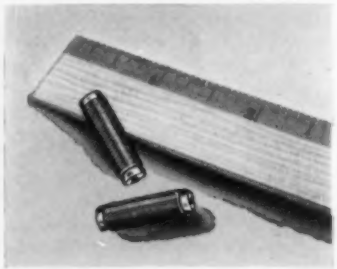
Production News from Bridgeport Thermostat

FROM THIS ALL-NEW PLANT— MORE AND BETTER BELLOWS

On its new 15-acre site at Milford, Conn., Bridgeport Thermostat now has 180,000 square feet of automated production facilities to assure quick delivery of all the bellows or bellows assemblies you need . . . at the lowest possible cost. A temperature and humidity controlled room for charging bellows assemblies is only one of the many ways in which this ultra-modern plant promises you bellows assemblies of consistently high quality.

¼" DIAMETER BELLOWS

Progress at Bridgeport is typified by this tiny bellows for miniaturization. Available in seamless design with a wide range of characteristics in brass, phosphor bronze, beryllium copper and monel. Larger sizes available.



Robertshaw-Fulton CONTROLS COMPANY

BRIDGEPORT THERMOSTAT DIVISION • MILFORD, CONN.

Please send me the following information: (Dept. NP-125)

☐ Full details on small-diameter bellows.

☐ Bellows Engineering Bulletin.

NAME_____

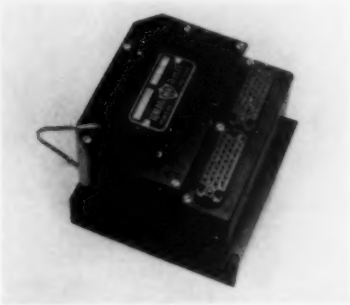
COMPANY_____

ADDRESS_____

CITY_____ ZONE_____ STATE_____

The unit can be attached to any universal motor from 1/50 to 1/15 hp rated for 115 v operation without any wiring changes. CGS Laboratories, Inc., 391 Ludlow St., Stamford, Conn.

For more information— Circle 69, inside back cover

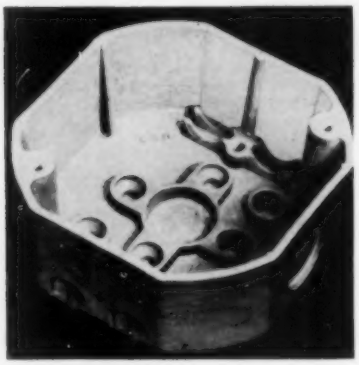


Three-Pole Sampling Switches

These switches provide constant force brushes, precision phasing, one to three poles, up to 60 shorting or 30 non-shorting channels per pole, complete with 6, 12, or 28 v, d-c motor, shielded rf filter, spur gear reduction. Also available with speed governor. Plugs recessed and mounted into housing.

Approximate dimensions are 2.687x 3.625 in. square. General Devices Inc., Princeton, N. J.

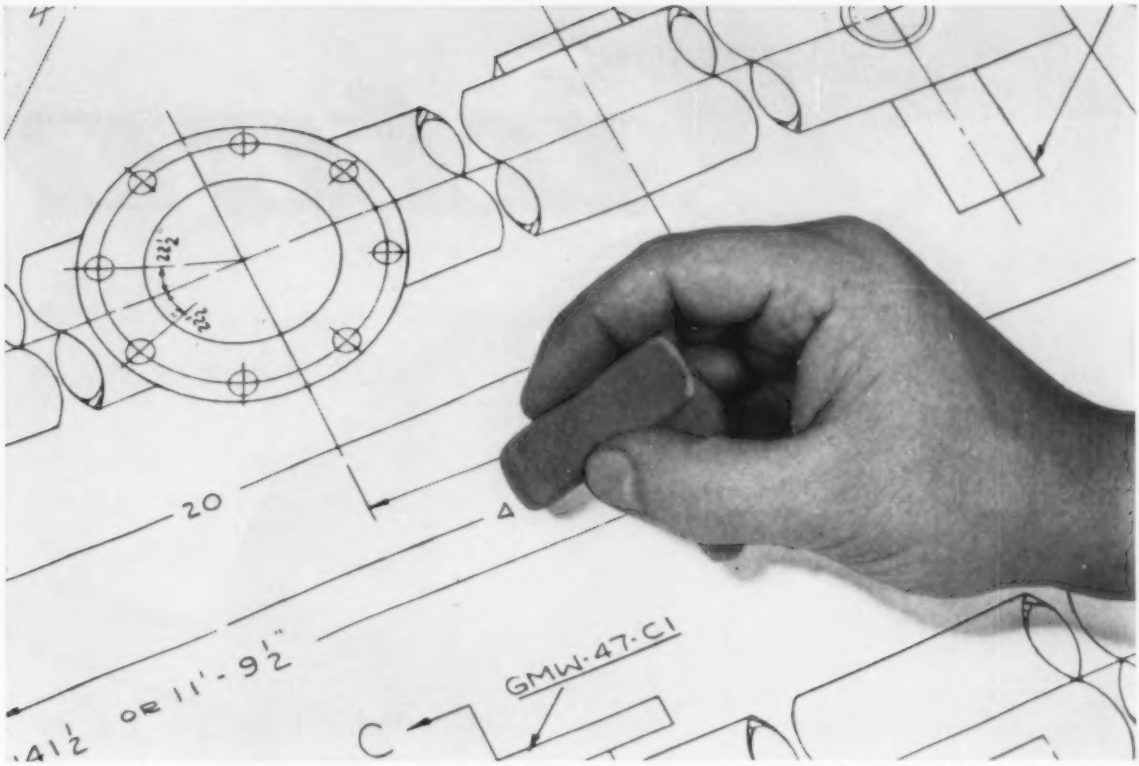
For more information— Circle 70, inside back cover



Glass Fiber Reinforced Outlet Box

The fully insulated box is said to eliminate need for grounding on many circuits. The unit is available with standard round knock outs, completely

(Continued on page 262)



Photographic lines on a Kodagraph Autopositive Paper Translucent intermediate can be quickly removed with ordinary eraser.

To simplify design changes

How can you make changes in a drawing—but still keep the original design intact—without costly retracing? In thousands of drafting rooms they follow this short cut: *Reproduce the drawing on Kodagraph Autopositive Paper Translucent.*

This gives you a positive photographic intermediate *directly*, without a negative step or darkroom processing. Remove the unwanted detail from this print with a moistened pencil eraser. Add the new design with pencil or ink—and presto! *You have a new print-making master* on high-quality vellum-type paper, which will turn out sharp, legible blueprints or direct-process prints at fast machine speeds.

This is just another example of the way you'll save with low-cost Kodagraph Materials, which you, or your local blueprinter, can process quickly.

EASTMAN KODAK COMPANY
Graphic Reproduction Division, Rochester 4, N. Y.

New booklet is jam-packed with valuable tips on saving drafting time, protecting drawings, getting better prints.

Kodagraph Reproduction Materials

MAIL COUPON FOR FREE BOOKLET

EASTMAN KODAK COMPANY 7-15
Graphic Reproduction Division, Rochester 4, N. Y.
Gentlemen: Please send me a free copy of your new booklet on Kodagraph Reproduction Materials.

Name_____ Position_____
Company_____
Street_____
City_____ Zone_____ State_____

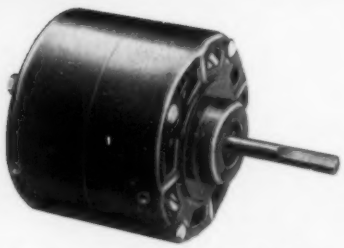
Kodak
TRADE MARK

Sutco

NEW!
THE SUTCO
MINI-LAP*

A completely new concept of permanent, split-capacitor motor design... sets new standards for minimum motor cost... plus higher efficiency
Type 6C — up to ⅓ H. P.
1050 R. P. M.

* *Patent Pending*



4-Pole Type **4D** — up to 1/8 H. P. 1,550 R. P. M.

WRITE TO: SUTCO, ORIGINAL EQUIPMENT DIVISION

MOTORS

A FAMILY OF SHADED-POLE MOTORS— BUILT TO YOUR EXACT SPECIFICATIONS

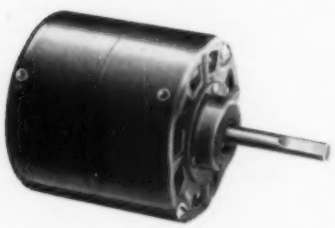
Sutco provides you with a completely new design in shaded-pole motors for quieter operation and lower cost. Adaptable for automation, Sutco Standard Shaded-Pole Motors are available in the following ratings:

• 2-POLE — UP TO 1/60 H. P. • 4-POLE — UP TO 1/8 H. P. • 6-POLE — UP TO 1/4 H. P. †

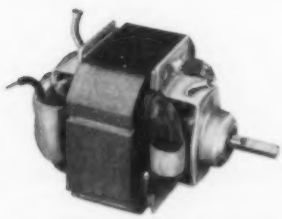
† *6-Pole — Type 6D — 1050 R. P. M. using same frame as Mini-Lap Motor*

All Sutco Mini-Lap and larger Shaded-Pole Motors provide positive lubrication to rigid-type babbit bearings. Highest quality insulation impregnated for moisture resistance to assure reliable performance under unfavorable conditions.

Whatever your requirements in shaded-pole or permanent, split-capacitor, fractional horsepower motors — *Sutco can meet them.* Refer your motor requirements to our staff of competent sales and product engineers for the most economical recommendations for your applications.



4-Pole Type **4C** — up to 1/25 H. P. 1,550 R. P. M.



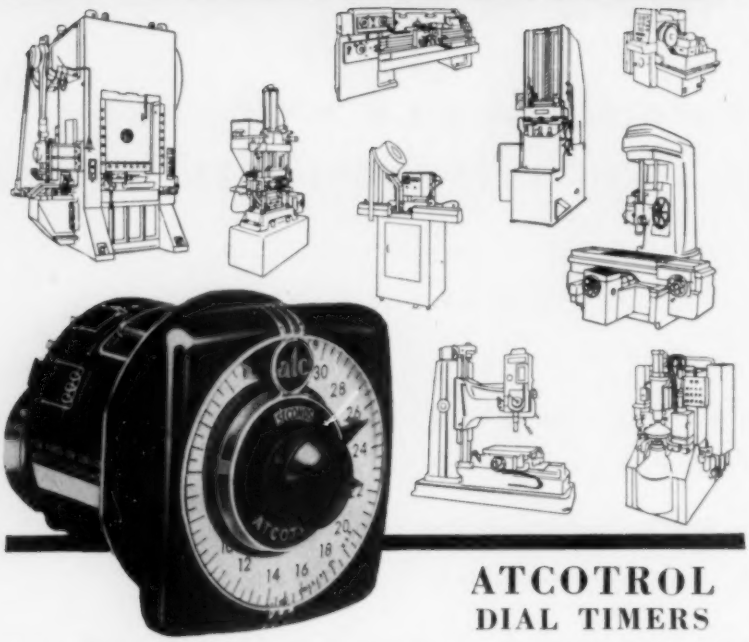
2-Pole Type **2A** — up to 1/60 H. P. 2,500 to 3,200 R. P. M.

Sutco
ORIGINAL EQUIPMENT

THE O. A. SUTTON CORPORATION, INC., WICHITA, KANSAS

For Equipment Manufacturers . . .

SIMPLE, COMPACT, PRECISE AUTOMATIC CONTROL



ATCOTROL DIAL TIMERS

. . . a new high in performance . . . a new low in cost

Whether your needs are for one timer per unit or for banks of timers to control an intricate process, investigate Atcotrol Timers now.

They hold costs down so many ways . . . the initial cost is only about $45.00 . . . the installation is fast, only one hole with filed notch . . . and if you require many different ranges, a small inventory will suffice.

Atcotrol handles up to four load circuits in more than 147 circuit arrangements . . . either reset or non-reset.

Unique non-slip clutch, with infinite engagement, provides high repeat accuracy. No lubrication is ever required. Complete service requires but a screwdriver and a set screw wrench.

You have to see Atcotrol in action to fully realize its many advantages!

FREE TRIAL OFFER TO EQUIPMENT MANUFACTURERS
You can fully evaluate Atcotrol performance on the equipment you manufacture, under your operating conditions, in your laboratory, without obligation. An Atcotrol will be sent to you for test purposes, without charge, for as long as you need it.

atc®
AUTOMATIC CONTROL SYSTEMS & COMPONENTS

AUTOMATIC TEMPERATURE CONTROL CO.
Subsidiary of Safety Industries, Inc.
5244 Pulaski Avenue, Phila. 44, Pa.

Please send me an Atcotrol on consignment, for test purposes.

NAME_____

COMPANY_____

STREET_____

CITY_____ **ZONE**____ **STATE**_____

IN CANADA: POWERLITE DEVICES, LTD., TORONTO, MONTREAL AND VANCOUVER

sealed and permitting the use of standard connectors. Octagon box is furnished with or without internal clamps. Porcelain Products, Inc., Findlay, Ohio.

For more information—
Circle 71, inside back cover

Silent Bin Vibrator

Weighing 25 lb this device is designed for use on hoppers, bins, chutes, packers, and all other bulk handling equipment. Built on the rotating eccentric weight principle, the vibrator is said ot make no more noise than an electric motor. The unit is electrically operated and is available in all common voltages, ac only. It draws 100 w, delivers a 275 lb impact, and comes with mounting plates for either portable or permanent installation. Cleveland Vibrator Co., Cleveland 13, Ohio.

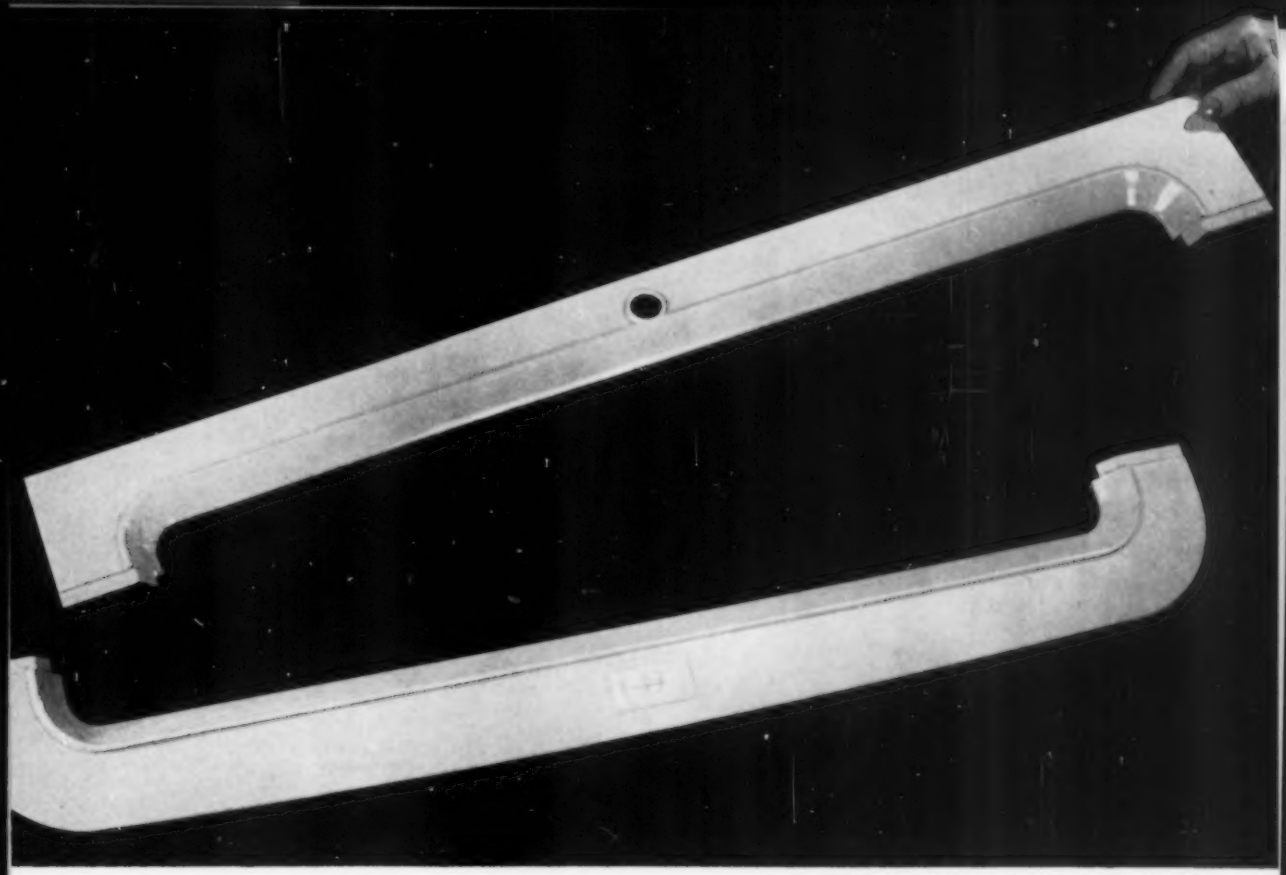
For more information—
Circle 72, inside back cover

Acceleration-Sensitive Switch

Suitable for use where instruments, controls, or safety devices are required to operate at a pre-determined acceleration level, the unit has a snap-acting switch element capable of being set precisely, in manufacture, to open or close when the desired G level is reached. Two basic styles are available: a momentary-contact unit that operates at the rated level and snaps back to its initial position when the acceleration falls below this level, and a manually reset unit that latches in its operated position until the reset button is pushed. Both styles are available in explosionproof case, or in hermetically sealed housing. Models with integral time-delay are also available.

These switches are rated at 30 v, 1 amp inductive or 2 amp, resistive load.

(Continued on page 266)



Breaker strips molded of impact styrene are used on door and door frame of refrigerator made by **Hotpoint Co.**, Chicago 44, Ill.

Why breaker strips for Hotpoint are BAKELITE impact styrene

TRADE-MARK

The new "Hotpoint" refrigerator points up two important features of BAKELITE Brand Impact Styrene TMD-5151, the material from which its breaker strips are molded.

One feature is toughness—the ability to stand up under the day-in, day-out succession of impacts even at —40 deg. F. The other feature is style—the perfectly-reproduced mold details, the uniformly matched color, the outstanding surface gloss that withstands household cleaning solutions.

Do your products need this combination of performance and appearance qualities? Take a look at BAKELITE Impact Styrene TMD-5151. It's just one of several Bakelite Company materials at work in electrical and refrigeration applications. To help fit the right one to your needs, Bakelite Company offers qualified technical assistance. Write Dept. PS-145 for information.

BAKELITE BRAND PLASTICS

BAKELITE COMPANY

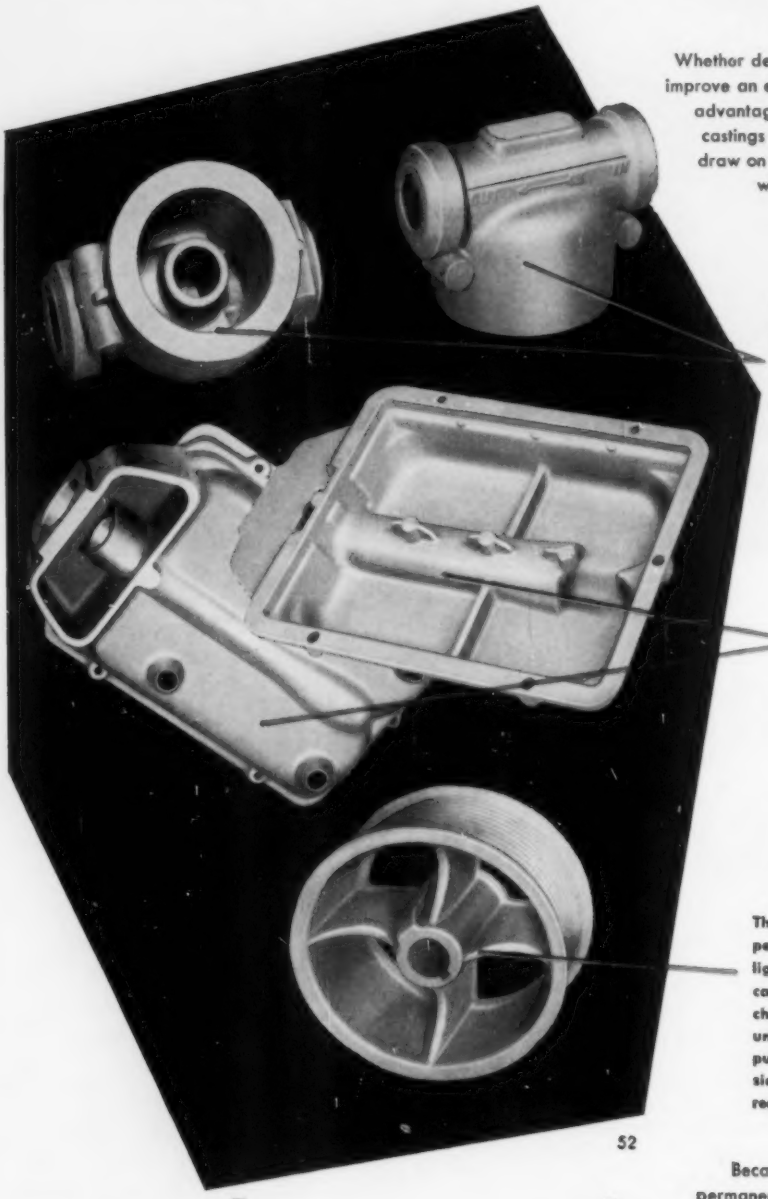
A Division of Union Carbide and Carbon Corporation UCC 30 E. 42nd St., N. Y. 17, N. Y.

In Canada: Bakelite Company, Division of Union Carbide Canada Limited, Belleville, Ontario

The term BAKELITE and the Trefoil Symbol are registered trade-marks of UCC

improving product characteristics by converting to precision

centr-O-cast aluminum castings



Whether designing a new product or looking for ways to improve an established one, you should consider the many advantages to be obtained with high quality aluminum castings from Centr-O-Cast. At Centr-O-Cast, you can draw on the vast knowledge of our engineers for help with your design, and on the experience of our molding section to produce the finest parts from that design.

Part of the high-pressure hydraulic system in an aircraft, this casting must be of minimum weight yet possess the strength to withstand 3750 lbs. bursting pressure. No porosity or inclusions are therefore allowable, and uniform quality is essential. In its heat-treated condition as supplied by Centr-O-Cast, this aluminum alloy casting machines as smoothly and accurately as the finest of free-cutting steels. Thus accurate tolerances in chambers and thread diameters are easily maintained.

Originally produced in cast iron, this burner housing is now cast of aluminum in a cored permanent mold by Centr-O-Cast. The decrease in weight has lessened shipping costs, and made the finished unit easier to suspend in use. The cast-in holes and the accuracy of the permanent mold eliminate the need for machining on the flat surfaces and reduce the amount needed on the cored holes and formed flange. The smoother internal surfaces result in better gas flow and the natural aluminum gives desired reflection.

This overhead door pulley is cast from aluminum in permanent molds. In addition to the high strength and light weight inherent in aluminum, the accuracy of the casting results in a center hole so precise that machining is not needed. And the spiral grooves are so uniform in diameter and correctly spaced that the pulley winds evenly, without danger of raising one side of the door before the other. The aluminum part requires no paint, and resists weathering.

52

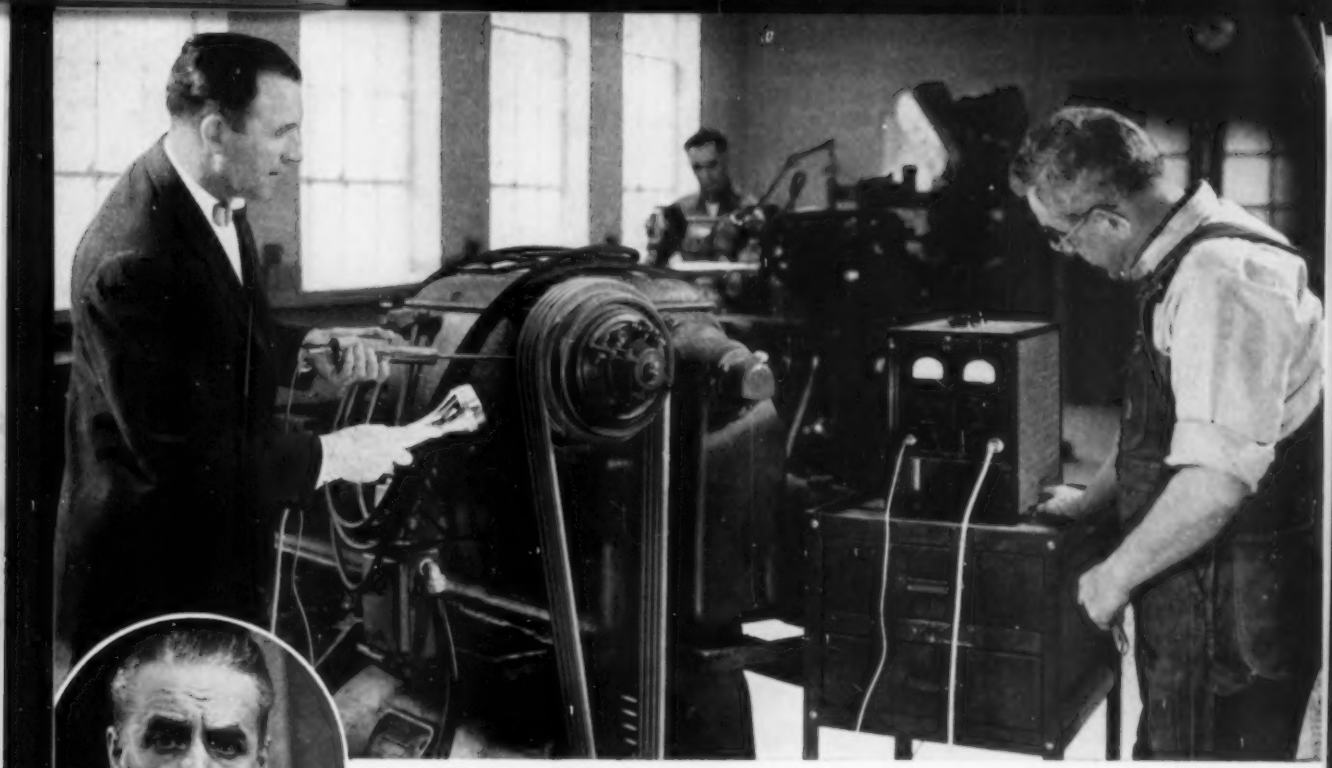
centr-O-cast

CENTR-O-CAST AND ENGINEERING COMPANY

45 St. Jean Avenue, Detroit, Michigan

Because we work with many molding techniques—permanent mold, semi-permanent, centrifugal or centrifuge—our engineers are not limited in their recommendations and can better assist you in choosing the right casting method for your product. We work in all the aluminum alloys, have heat-treating facilities, and are equipped to produce castings ranging from 2 ounces to 65 pounds.

Write for our illustrated brochure or a personal call by our casting consultant.



Belt vibration is a design headache . . . eliminate it by specifying Veelos!

1 This test proves Veelos V-belts cut vibration up to 90%

Why chance running into vibration troubles when Veelos V-belts stop belt vibration before it starts. Particularly in designing for air conditioning, ventilating, refrigeration and precision equipment where belt vibration and noise are costly factors . . . *you owe it to yourself to see the Veelos Vibration Test* (above), before you specify. This test proves Veelos cuts vibration up to 90% over any belt you're using. The vibration story can become a big factor in selling your machines. With Veelos Belts you *assure* your customers of less bearing wear, less spoilage and less downtime.

2 Specify Veelos for a smoother-running drive

Ordinary V-belts have varying spots of density, due to their construction, which throw them out of balance. Veelos Belts are absolutely uniform; every stud and link identical; every foot of the reel is perfectly balanced. The beveled links, the machine-cut sides add up to better vibrationless performance. And by specifying Veelos, you're doing yourself a big favor . . . because your customers will be more pleased with the added efficiency of your machines. Your Veelos salesman can give you proof that Veelos outperforms any other V-belt, by test, right before your eyes.

3 Veelos allows you complete design freedom, too!

With Veelos you fit the belt to the drive, not the drive to the belt—because Veelos is adjustable to any length. You can use outboard bearings to advantage because Veelos is installed easily without dismantling any part of the machine. With Veelos you need not design for belt adjustment—no idler, no slide rail or any other belt-tightening device is needed. Simply add or delete links; that's all; no tilting or moving motors. A 15 minute demonstration shows you the many advantages Veelos offers.

© M.M.&B. Co. 1956

VEELOS
THE BALANCED
LINK V-BELT

Veelos is known as Veelink outside U.S.A.

For free vibration demonstration and Veelos Data Book write to:

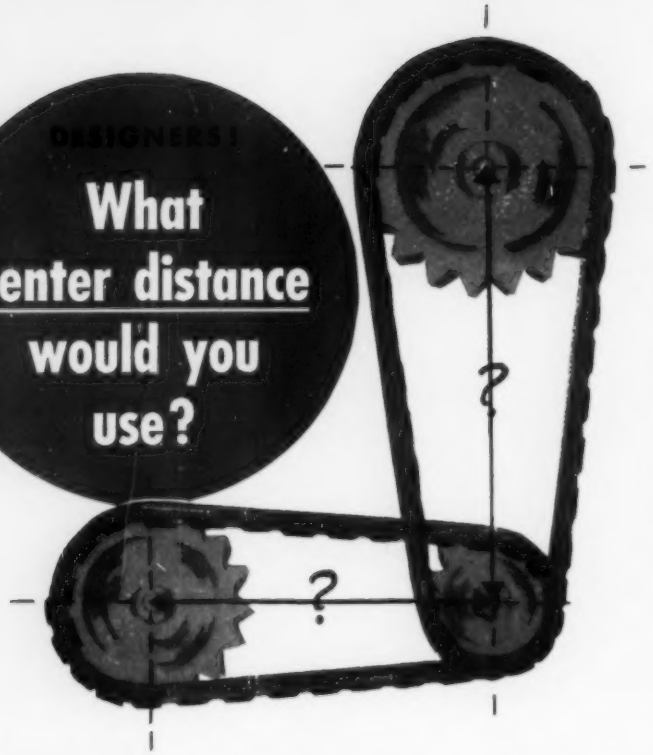
MANHEIM

Manufacturing & Belting Company
207 Stiegel St., Manheim, Pa.

"Industrial Belt Specialists Since 1911"

DESIGNERS!

What center distance would you use?



Maximum power transmission efficiency is obtained when the center distance, in each case, is correct.

Center distances must be more than one half the diameter of both sprockets (otherwise the teeth would touch). Best results are obtained when a center distance of 30 to 50 times the pitch of the chain is used. Eighty times the pitch is considered maximum. For pulsating drives, the center distance should be shortened to 20 to 30 times the pitch. Chain sag should be equivalent to approximately 2% of the center distance.

ACME ENGINEERS OFFER FREE ADVISORY SERVICE. Whatever the problem, Acme Chain Engineers are always willing to lend a hand. Call direct to Acme for sound advice or field assistance.

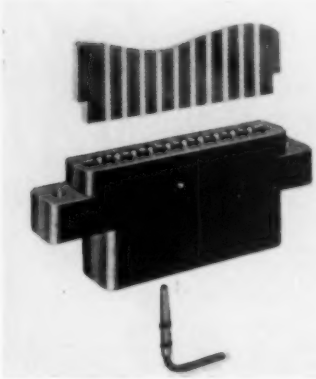
FREE TEXT. Designers and engineers may write for a free copy of this 76 page chain text. It's loaded with chain data, specifications, illustrations and facts you should know about chain applications. Write ACME CHAIN CORP., Dept. IE Holyoke, Mass.

Write or Call JE 2-9458 for immediate delivery or engineering service.

Acme Chain Corporation
HOLYOKE MASSACHUSETTS

They can be furnished to operate at any level from 2.5 to 15 G absolute with precision of ±0.2 G. Frequency range is 0 to 10 cps. W. L. Maxson Corp., 47-37 Austell Pl., Long Island City 1, N. Y.

For more information—
Circle 73, inside back cover



Printed Card Receptacle

The two isolated rows of contacts are made of heat-treated beryllium copper, silver-plated with gold flash. Insulating body is available in glass reinforced alkyd to meet rigid mechanical and electrical specifications. Receptacles can be supplied with or without snap-in polarizing pins. Available with 6, 10, 15, 18 and 22 contacts per row, for $\frac{1}{8}$ and $\frac{3}{32}$ in. printed cards, these receptacles have an insulation resistance of over 100,000 megohm and voltage capacity of 2200 v, ac (rms), at sea level, and 600 v, ac (rms), at 60,000 ft. U.S. Components, Inc., 454 E. 148 St., New York 55, N. Y.

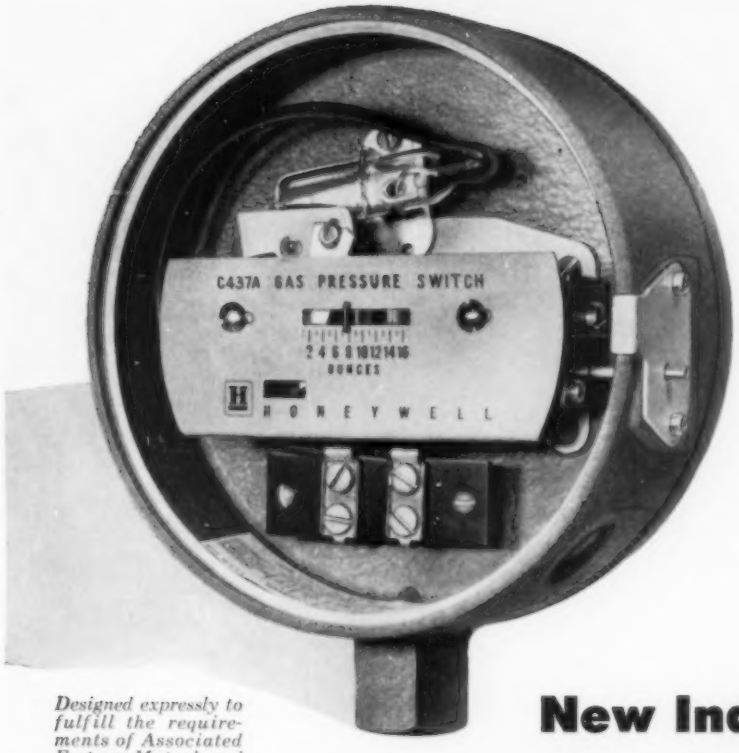
For more information—
Circle 74, inside back cover

Door Interlock Switch

A subminiature interlock switch, designed for use on radio, radar, X-ray and other hazardous high-frequency equipment cabinets, is designed to cut off power automatically when a service door is opened. By pulling a rod actuator to the maintained contact position, it is possible to check circuits with the power on. The rod automatically returns to normal position when a door is closed.

The total travel in either direction

(Continued on page 271)



Designed expressly to fulfill the requirements of Associated Factory Mutual and Underwriters' Laboratories.

New Industrial Gas Pressure Switch offers 4 exclusive safety features

USE this new Honeywell C437A Industrial Pressure Switch as a safety cutoff on multiple burner gas installations . . . as a pressure controller for hazardous gases . . . or as a differential controller for air or non-hazardous gases. It's simply designed, yet provides complete protection.

The C437A Industrial Gas Pressure Switch has these exclusive safety features:

1. Sealed Pressure Chamber—Should the diaphragm rupture from over pressure or any other cause, gas can't escape into the switch compartment or to the atmosphere. The pressure chamber is fitted with a pipe tap to permit venting to the stack.

2. Protected Settings—All adjustments are inside the case for protection against careless or accidental manipulation. A metal plate on the side of the case must be removed before changes in adjustment can be made.

3. Ever-Visible Switch Position and Control Settings—The entire cover of the pressure switch is a window. Position of the mercury switch and adjustment of the control settings can be determined at a glance.

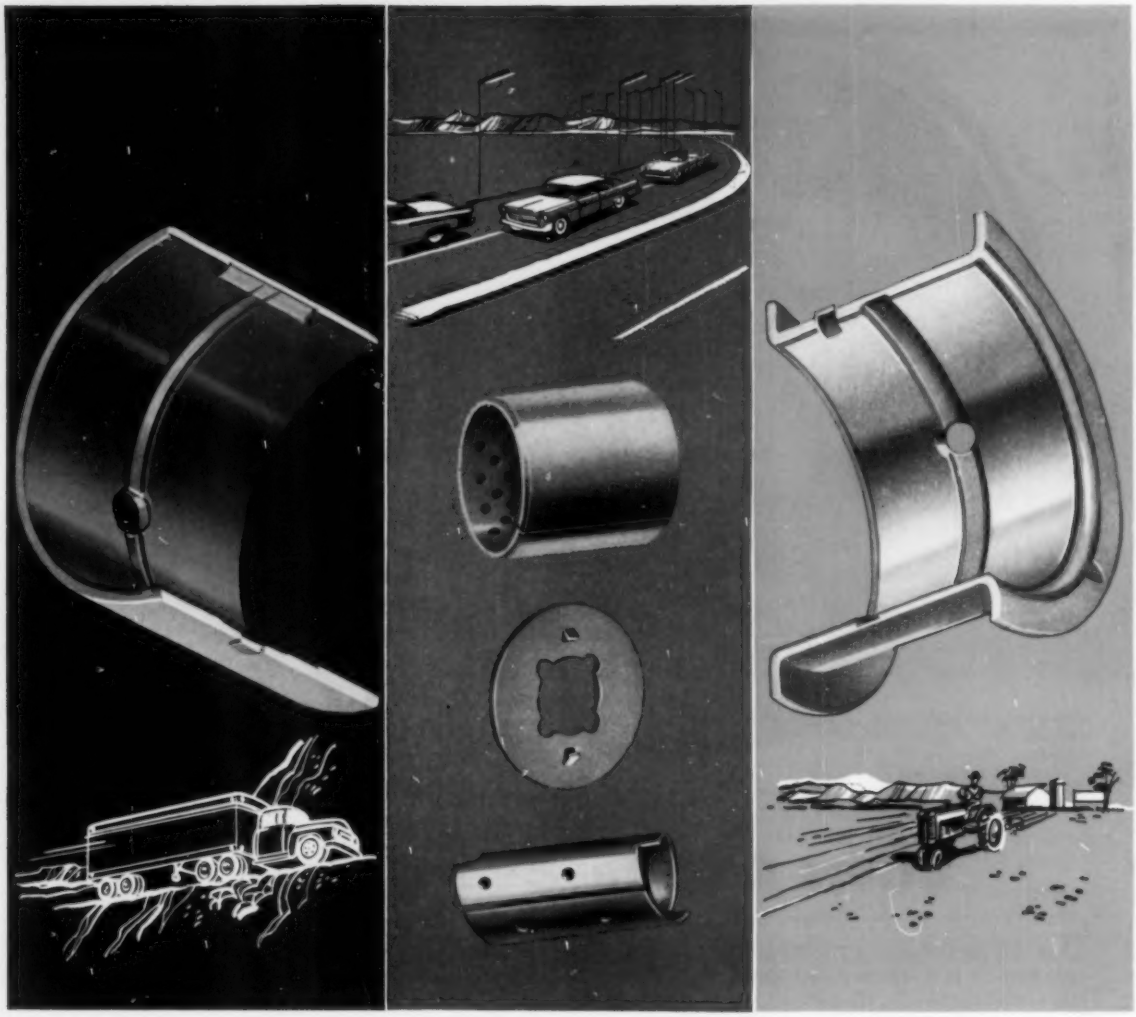
4. Lockout Mechanism—An optional safety feature, when manual resetting is desired. The lockout mechanism prevents the switch from remaking contact after pressure has once dropped below the setpoint . . . even though pressure returns to normal. The lockout release button is the only adjustment that can be manipulated without removal of the protecting metal plate.

For complete information, call the nearest Honeywell office. A Honeywell sales engineer is as near as your phone.

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, Wayne and Windrim Avenues, Philadelphia 44, Pa.—in Canada, Toronto 17, Ontario.

● **REFERENCE DATA:**
Send for Specification S1011-1 Honeywell Gas Pressure Switch C437A

MINNEAPOLIS **Honeywell**
BROWN INSTRUMENTS
First in Controls



RESEARCH • DESIGN • METALLURGY • PRECISION MANUFACTURING

Our 56 years of specialized experience is part of every one of the millions of sleeve bearings we produce each year. It means that each of these bearings will meet the most exacting requirements of practically every type of automotive, industrial and agricultural equipment. We maintain complete facilities for research and engineering, and quality control in all of our plants.

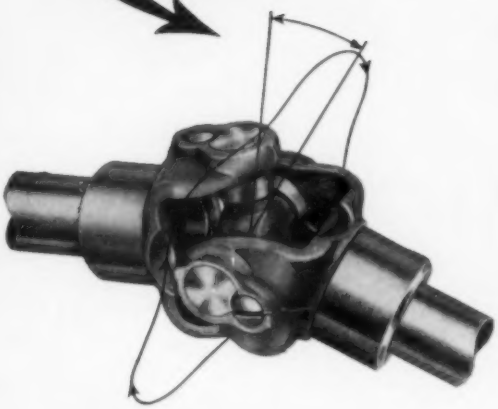
FEDERAL-MOGUL DIVISION

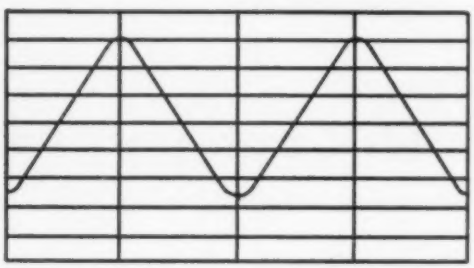
FEDERAL Mogul

SINCE 1899

FEDERAL-MOGUL-BOWER BEARINGS, INC., 11043 SHOEMAKER, DETROIT 13, MICHIGAN

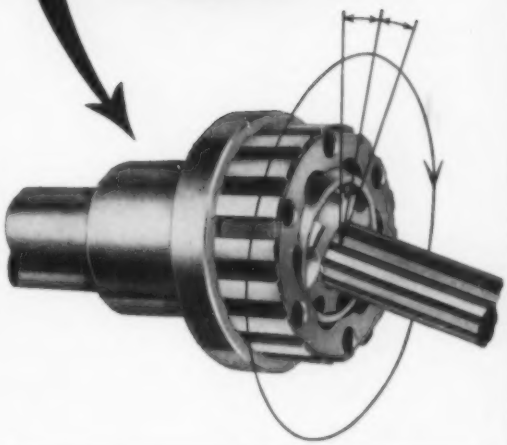
This Action Costs You Money

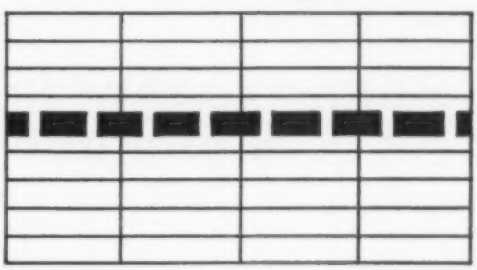




During rotation at a given angle, pin or slipper-type joints speed up, slow down twice during one revolution, as shown by the solid line in the graph.

This Action Saves You Money





Rzeppa Joints *always* transmit torque smoothly, even at unbalanced angles. Note constant velocity of 100% for Rzeppa Joint (dotted line).

Are You Getting The Design Advantages Of Constant Velocity?

The simple illustration above shows how Rzeppa Constant Velocity Joints transmit torques smoothly—and profitably—on many of today's most advanced designs.

Machinery and equipment of all types can take advantage of Rzeppa's unique design. It makes possible these money-saving features:

- INCREASED SPEEDS
- REDUCED DOWN-TIME
- LOWER MAINTENANCE
- GREATER ANGLES

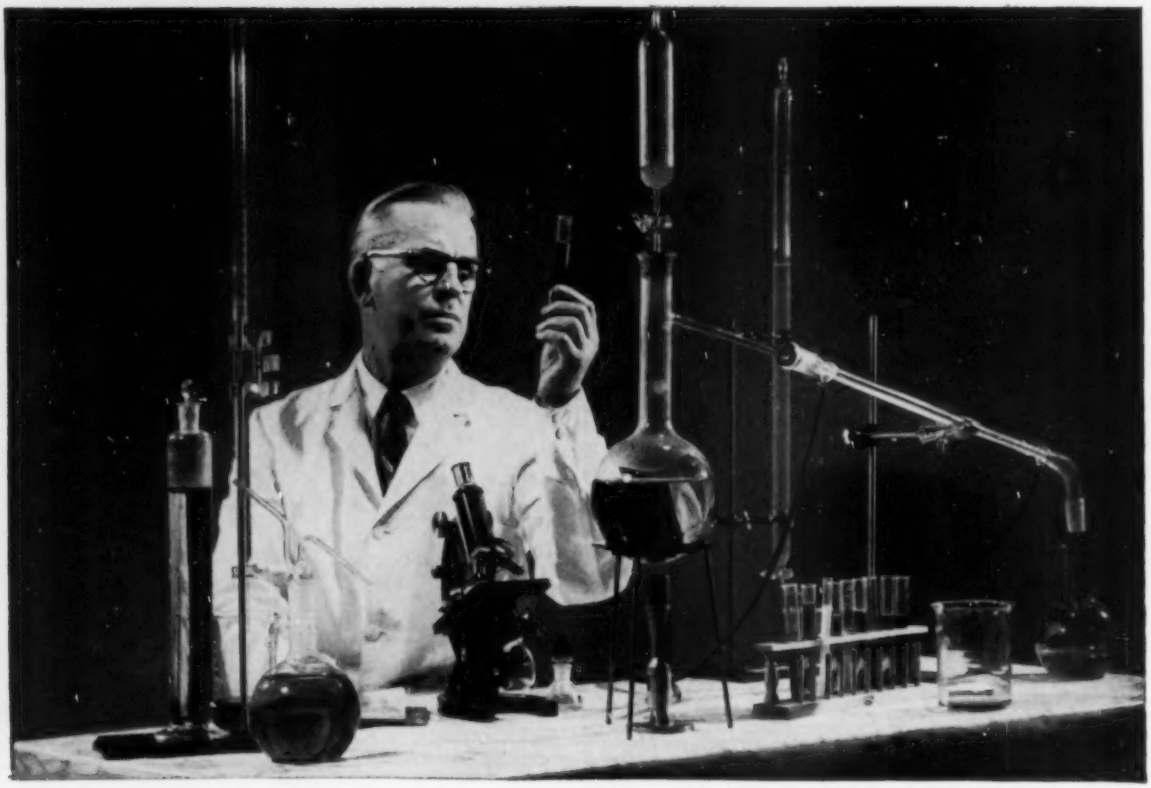
Why not investigate? Write today for descriptive literature.

RZEPPA "SHEPPA" CONSTANT VELOCITY UNIVERSAL JOINTS

THE GEAR GRINDING MACHINE COMPANY

3939 Christopher, Detroit 11, Michigan

Manufacturers of: Fully Automatic Gear Grinding Machines • Detroit Screwmatic 750 single spindle screw machine.



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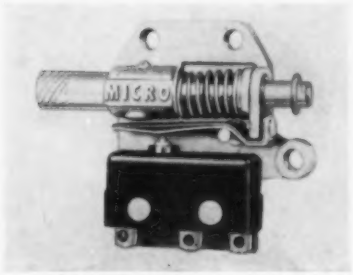


of the actuator plunger is $\frac{5}{32}$ in., approximately. The over-all size of the assembly is $1\frac{13}{32}$x$\frac{27}{32}$x$1\frac{1}{4}$ in. The electrical rating is: 5 amp, 125 or 250 v, ac; 30 v, dc (inductive or resistive). Sea level, 3 amp; 50,000 ft, 2.5 amp. Maximum inrush is 15 amp. Micro Switch, Div. Minneapolis-Honeywell Regulator Co., Freeport, Ill.

For more information—
Circle 75, inside back cover

Rotary Sector Potentiometer

Housed in a cast aluminum case, this potentiometer is designed to withstand up to 40 lb side load on the shaft while operating. It is also gasket and O-ring sealed against immersion to 15 psi.

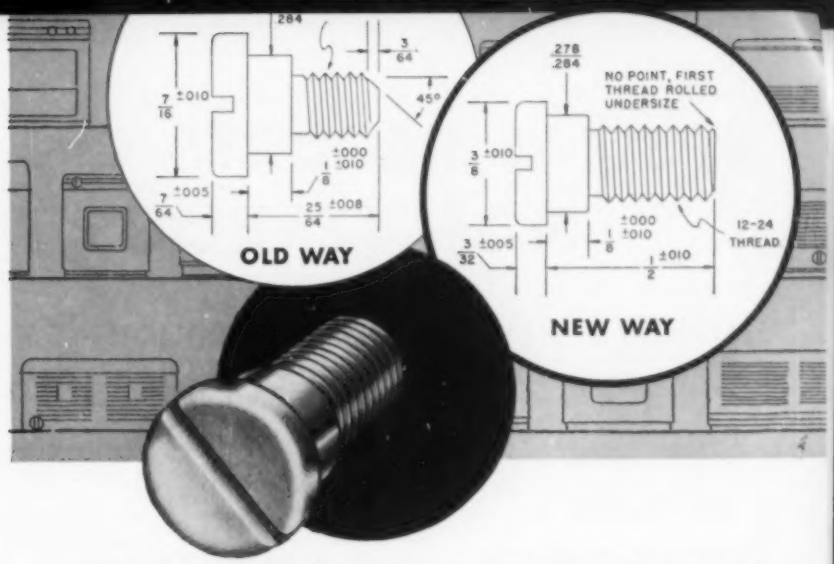
The unit is rated at up to 2 w dissipation per element. Up to 110 deg active travel, 5 deg overtravel each end, is possible. Resolution, 1/17 deg. MINCO Engineering & Mfg., 801 8 St., S.E., Minneapolis 14, Minn.

For more information—
Circle 76, inside back cover

Control Transformers

According to the manufacturer, this series of transformers was designed with five primary and four secondary taps to provide a selection of connec-

(Continued on page 274)



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The two parts shown above demonstrate how Townsend engineers saved an appliance manufacturer $5.00 per thousand by redesigning a special fastener so that it could be produced by cold-forming. By redesigning this part a costly machining operation was eliminated.

The shouldered screw at left, above, an integral part of a major appliance, was originally produced by another method at a cost of about $10.00 per thousand. Townsend engineers applied their extensive knowledge of cold-forming techniques to the problem and by slightly changing the design found that the part could be produced for about $5.00 per thousand—a clear savings of 50% on a part used in great volume. The new part shown at right provides just as efficient a fastener as the old.

This is a typical example of how the Townsend Technical Sales Department can help you in your efforts to improve your products and reduce assembly costs. These men can serve you in several ways—they will act as fastening consultants to your design and production engineers—they will design special parts or recommend the best standard fasteners. They often study an entire assembly procedure and suggest improved techniques.

The Technical Sales Department has back of it a company with nearly a century and a half of wire drawing and cold-forming experience. Townsend regularly produces more than 10,000 standard and special parts and fasteners—has the capacity to manufacture more than 60-million pieces a day.

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SPECIAL REPORTS ON FINISHING NON-FERROUS METALS

NUMBER III—Lustrous, Corrosion-Resistant Finishing with Chemical Polishing Iridite

WHAT IS IRIDITE®?

Briefly, Iridite is the tradename for a specialized line of chromate conversion finishes. They are generally applied by dip, some by brush or spray, at or near room temperature, with automatic equipment or manual finishing facilities. During application, a chemical reaction occurs that produces a thin (.00002" max.) gel-like, complex chromate film of a non-porous nature on the surface of the metal. This film is an integral part of the metal itself, thus cannot flake, chip or peel. No special equipment, exhaust systems or specially trained personnel are required.

Chromate conversion coatings are widely accepted throughout industry as an economical means of providing corrosion protection, a good base for paint and decorative finishes for non-ferrous metals. Certain of these coatings also possess chemical polishing abilities that have luster-producing, as well as corrosion-inhibiting, effects on zinc and cadmium plate, zinc die castings and copper alloys. However, continued developments in this field have been so rapid that many manufacturers may not be completely aware of the breadth of application of this type of finish. Hence, this discussion of the many ways in which this chemical polishing characteristic can be used in final finishing or pre-plating treatments to produce a lustrous appearance with distinct display and sales appeal and appreciable savings in cost. Report I on decorative, corrosion-resistant finishes and Report II on paint base corrosion-resistant finishes are available on request.

The degree of luster possible on a surface is a function of the degree to which the surface can be smoothed. Leveling to provide a smooth surface can be achieved by mechanical or chemical means, or a combination of these, depending upon the luster desired and the original condition of the metal. Chemical polishing effectively imparts luster otherwise difficult and costly to obtain. For this reason, it is often used to supplement or entirely replace mechanical polishing, depending upon the application and the original condition of the metal. Chemical polishing has the additional advantage of providing overall treatment of the submerged part. It reaches into even the deepest corners and recesses that are otherwise inaccessible. Certain of the Iridites are specifically designed to perform this chemical polishing operation. Also, they provide corrosion protection as do all Iridites, thus may be used as a final finish or a pre-plating polish.

If Iridite is to be used as a final finish, in contrast to pre-plating treatment, the chromate conversion coating generated is allowed to remain, providing good corrosion resistance. Color inherent in these Iridite films ranges from a yellow cast to yellow iridescent. These coatings may be used without further treatment where this color is acceptable and good corrosion resistance is desired. Further, these basic coatings can be tinted by dyeing. Among the dye tints available are shades of red, yellow, blue and green. If desirable, the basic coatings can also be modified by a bleach dip leaving a clear bright or blue iridescent finish. In all cases bleaching reduces corrosion resistance.

As examples of this type of final finishing, Iridites #4-73 and #4-75 (Cast-Zinc-Brite) make possible for the first time, lustrous chemical polishing of the as-cast surface of zinc die castings. Thus, in many cases, sizeable savings in finishing cost are realized by elimination of plating costs. This economical method can be used on tools, appliance parts, toy pistols, locks and many other small castings. Another example is the treatment of copper and brass parts, such as welding tips, to eliminate buffing and provide additional corrosion resistance. In many cases, handling costs are reduced appreciably by replacing piece-part handling with bulk processing. Still another example of the use of this chemical polishing and protective quality of Iridite is a simple system of zinc plate, Iridite and clear lacquer instead of more costly electroplated finishes. Typical of this type of lustrous finish are builders hardware and wire goods.

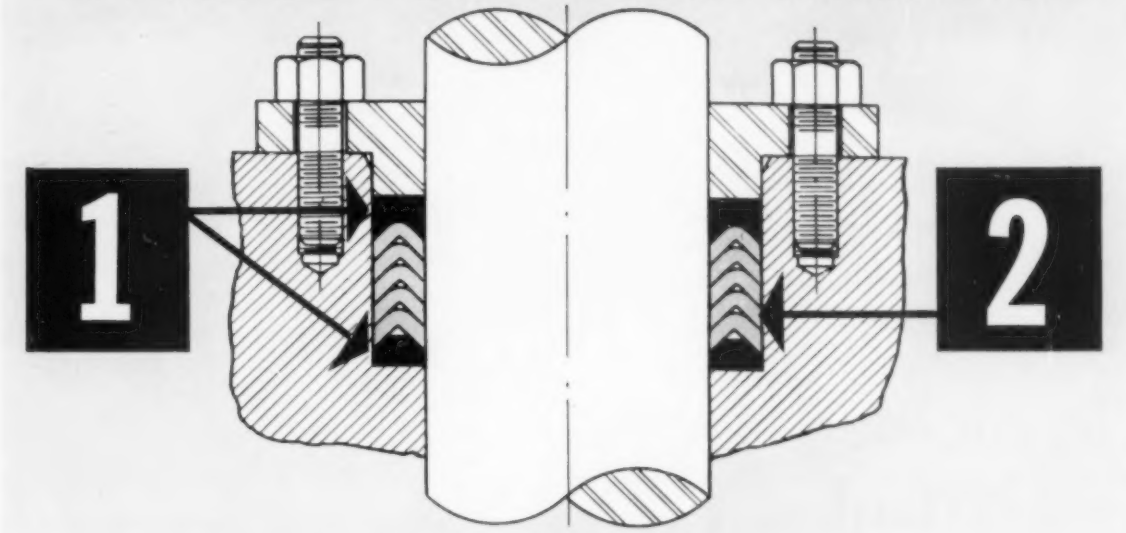
As a pre-plating treatment, in contrast to final finishes, Iridite can be used to chemically polish zinc die castings or copper prior to plating. In such cases, Iridite should be applied as an in-process step, so that the protective film is removed before the plating cycle. The savings in handling, material and labor costs are obvious. This process has made it practical to plate chrome directly over copper on steel, conserving nickel, yet producing a lustrous chrome finish. Used after stripping faulty plate in reprocessing zinc die castings, Iridite restores luster to the casting, thus making possible replating without blistering.

Other Iridite finishes are available to produce maximum corrosion resistance, a wide variety of decorative finishes and excellent bases for paint on all commercial forms of the more commonly used non-ferrous metals. As a final finish, appearance ranges from clear bright to olive drab and brown and many films can be bleached or dyed. As a paint base Iridite provides excellent initial and retentive paint adhesion and a self-healing property which protects bare metal if exposed by scratching. Iridites have low electrical resistance. Some can be soldered and welded. The Iridite film itself does not affect the dimensional stability of close tolerance parts.

Iridites are widely approved under both Armed Services and industrial specifications because of their top performance, low cost and savings of materials and equipment.

You can see then, that with the many factors to be considered, selection of the Iridite best suited to your product demands the services of a specialist. That's why Allied maintains a staff of competent Field Engineers—to help you select the Iridite to make your installation most efficient in improving the quality of your product. You'll find your Allied Field Engineer listed under "Plating Supplies" in your classified telephone book. Or, write direct and tell us your problem. Complete literature and data, as well as sample part processing, is available. Allied Research Products, Inc., 4004-06 East Monument Street, Baltimore 5, Maryland.

TWO NEW HOUGHTON "V" PACKING DEVELOPMENTS



SAVE TWO GLAND DESIGN JOBS

1

2

Houghton's new molded "V" Packing adapters do away with individually designed metal support rings. And besides saving you design work, they help "V" Packings make a better seal.

These molded rings can "give" under pressure, expanding to bridge the clearance. They'll flex without cracking. They're not subject to the fatigue that can break down metal rings. Because they expand along with packings Houghton Molded "V" Packing adapters provide better support and permit packings to give longer service.

Standard stack heights of Houghton "V" Packings give designers a break, too. When you use Houghton "V's" you don't need to design glands differently because packings of different materials will be used in them. Just figure the number of packings pressure requirements demand . . . then allow for the dimension in your design. Whether you use rubber, fabricated rubber, or leather "V's" . . . they'll fit. They are all the same stack height.

There's more than 50 years of hydraulic know-how behind these new design developments. They're typical of Houghton's complete line of hydraulic and pneumatic packings and hydraulic oils and fluids. For the full story, call your Houghton Man today—or write E. F. Houghton & Co., 303 West Lehigh Avenue, Philadelphia 33, Pa.

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tions for off-standard voltage supply applications. This unit can be used where primary voltage supply is 208, 220, 230, 240, 380, 400, 416, 440, 460, 480, 500, 550, 575 or 600 v. It will provide output voltage of 85, 91, 95, 99, 100, 110, 115, 120, 125 or 130 v.

This transformer is available in capacities of 50, 150, 250 and 500 va. Acme Electric Corp., Cuba, N. Y.

For more information—
Circle 77, inside back cover

Air Eliminator

A high pressure air eliminator for automatically venting equipment using steam pressures from 0 to 150 lb is designed for steam processing equipment, such as driers, steam coils, steam mains, unit heaters, laundry equipment. Gorton Heating Corp., Cranford, N. J.

For more information—
Circle 78, inside back cover

Self-Locking Anchor Nuts

Present configurations include a two-lug anchor nut plate, a corner anchor and a one-lug anchor. Anchor configurations are designed for appli-

(Continued on page 278)

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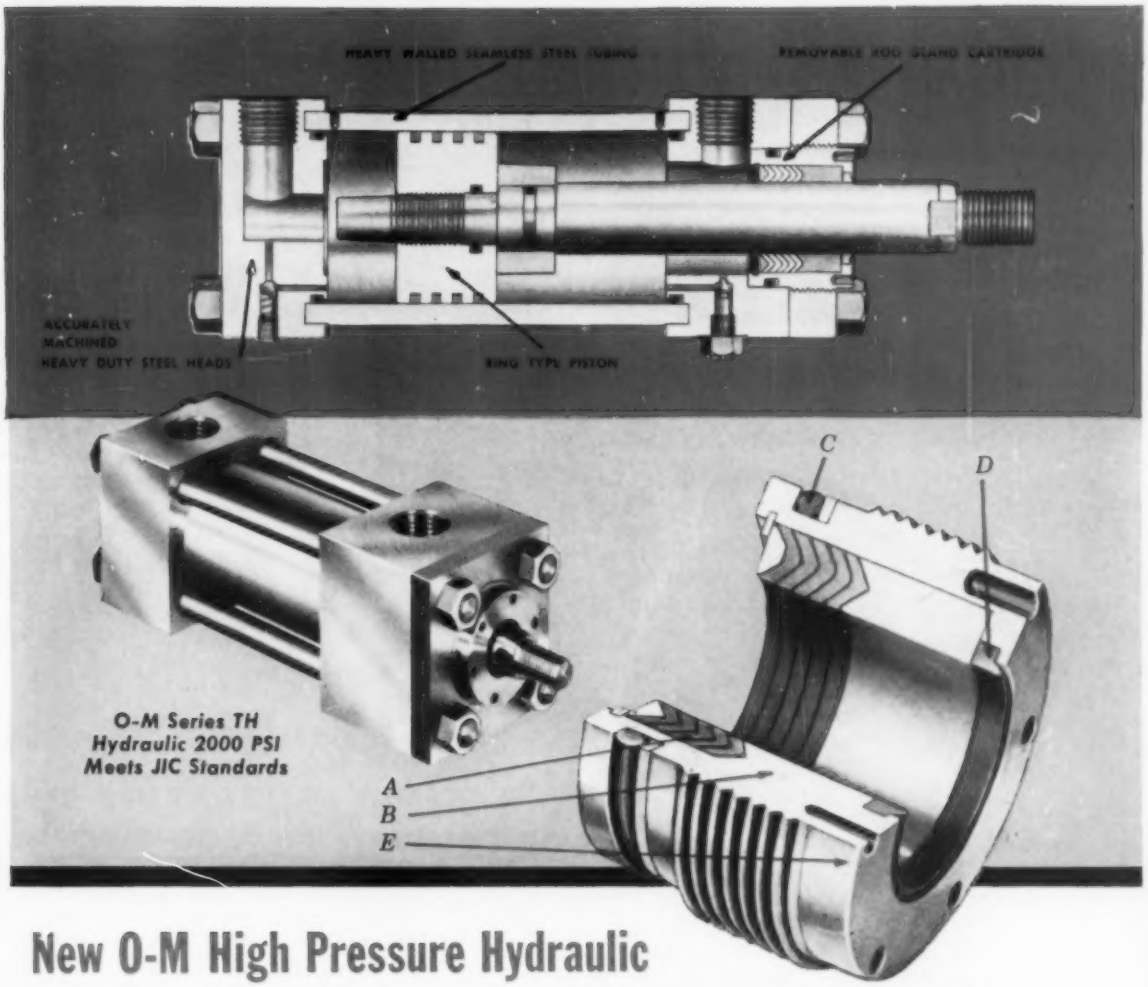

New O-M High Pressure Hydraulic Cylinder equipped with Removable Rod Gland Cartridge

The O-M-engineered removable Rod Gland Cartridge, exclusive with the O-M Series TH Hydraulic Cylinders, incorporates all the features essential to peak performance and minimum maintenance. It is constructed with a heavy wall steel shell threaded for quick, easy removal, and accurately piloted in rod head to assure perfect alignment. In most applications cartridge can be removed easily without removing mounts or the rod nuts. You simply loosen and remove with a spanner wrench.

A ***Rod Packing*** — Vee type, non-adjustable, self-compensating, rod gland packing provides multiple lip seal with excellent pressure sensitivity and long life.

B ***Rod Bearing*** — Extra long, bronze rod bearing provides large bearing surface located well forward for maximum support of piston rod.

C ***Cartridge "O" Ring Seal*** — With leather back-up washer provides positive seal and acts as friction lock to retain cartridge.

D ***Rod Wiper*** — Homogeneous lip type located well forward to prevent accumulation of dirt in pocket. Metallic scraper (AN approved) available and interchangeable with wiper.

E ***Pilot*** — O.D. of cartridge serves as pilot for cylinders mounted on rod end.

O-M Series TH High Pressure Hydraulic (oil) Cylinders — conservatively rated at 2000 P.S.I. — are available in bore sizes 1½ to 8-inch inclusive. Descriptive drawings of cylinder, mounts, mounting brackets and capacity chart are included in the new O-M Bulletin 105. Mail coupon for your FREE copy today.

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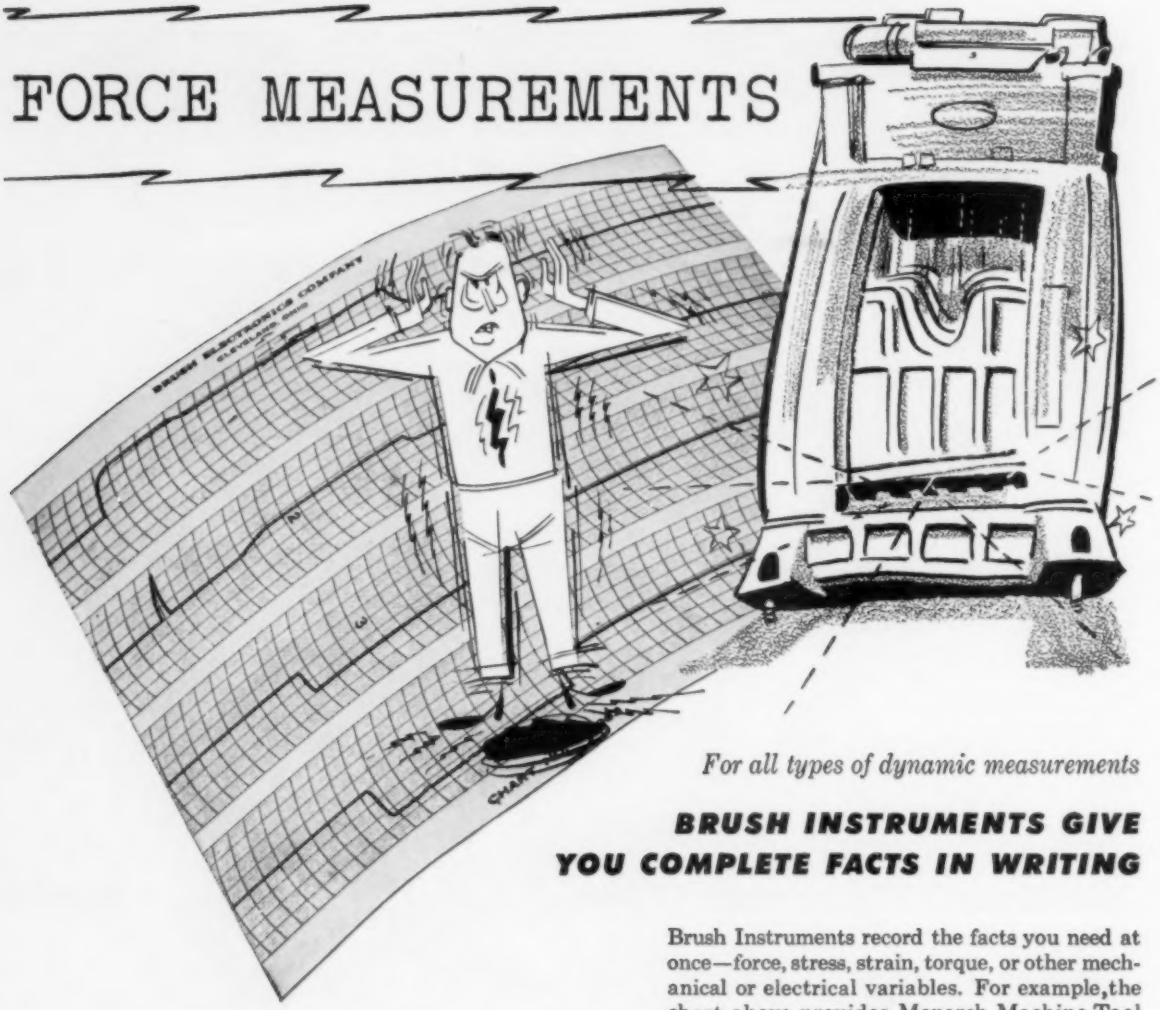
FORCE MEASUREMENTS



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Brush Instruments record the facts you need at once—force, stress, strain, torque, or other mechanical or electrical variables. For example, the chart above provides Monarch Machine Tool Company with important answers on the metal cutting process . . . answers obtained quickly and accurately with a minimum of engineering time.

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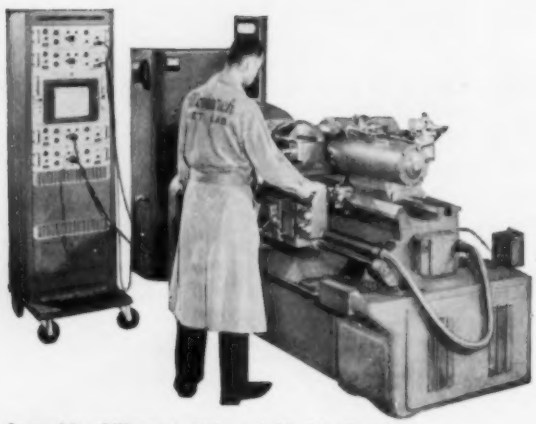
Brush offers a complete line of electrically controlled direct-writing recording systems for test laboratory or portable field use that can help you in virtually any measurement problem. Get the facts from your Brush representative. Or write for booklet to Brush Electronics Company, Dept. L-7, 3405 Perkins Avenue, Cleveland 14, Ohio.



In machineability test at Monarch Machine Tool Company, a complete written answer to the test problem is available before the spindle comes to rest.

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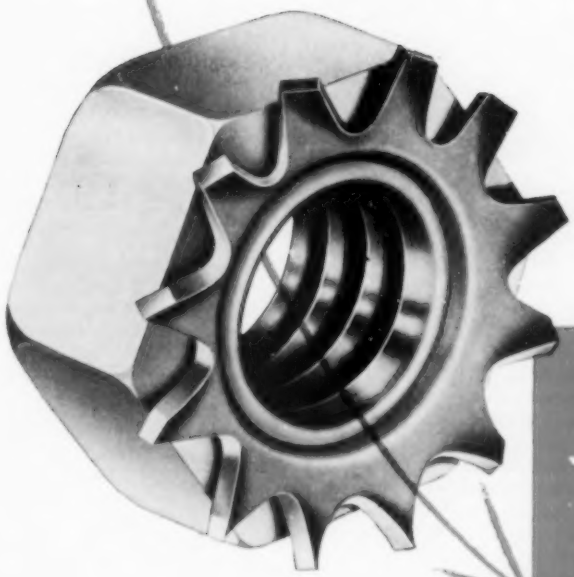

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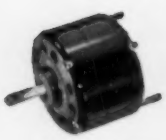


MODEL B
4-pole, 4-coil shaded pole AC Induction Type

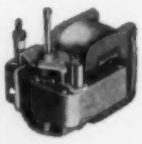
MODEL A
2-pole, shaded pole AC Induction Type

MODEL C
2-pole, shaded pole AC Induction Type

MODEL E
4-pole, shaded pole AC Induction Type

MODEL O
2-pole Capacitor Reversible Type AC only (for 6, 12, or 24 volts)

MODEL D
4-pole, 4-coil shaded pole AC Induction Type



MODEL F
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cations where the nut is "fixed" to the basic structure to provide a blind fastener in inaccessible locations. The offset-crown, self-locking device is said to assure safe, repeated reuse during maintenance and repair.

Made of carbon steel, heat treated and cadmium plated, for temperatures to 500 F, the three configurations are available in four thread sizes: 6-32, 8-32, 10-32 and ¼-28. Dept. 169, Elastic Stop Nut Corp., 2330 Vauxhall Road, Union, N. J.

For more information—
Circle 79, inside back cover

Pressure Reducing Valve

An air-loaded, diaphragm-operated, pressure reducing valve for steam heat and process steam applications is available in cast iron in sizes ½ to 2 in., with screwed end connections. Inlet pressure range is 0 to 250 psi, 450 F. The reduced pressure range is 0 to 85 psi, or, up to 249½ psi with any suitable high pressure loader. Leslie Co., Lyndhurst, N. J.

For more information—
Circle 80, inside back cover

Indicates Flow of 1 Gph

A low capacity indicator capable of reliably detecting flow as small as 1 gph through a pipe actuates a switch that can be used to operate a remotely

(Continued on page 281)

(Advertisement)

DESIGNING WITH ALUMINUM

This is one of a series of information sheets which discuss the properties of aluminum and its alloys with relation to design. Extra or missing copies of the series supplied on request. Address: Advertising Dept., Kaiser Aluminum & Chemical Sales, Inc., 1924 Broadway, Oakland 12, California.

NO. 20

ADVANTAGES OF ALUMINUM DIE CASTING

The die casting process permits high-volume manufacture of uniform, finely finished, highly complex aluminum parts at exceptionally low unit production cost. Among other advantages of aluminum die castings are high strength characteristics, low scrap loss and close dimensional accuracy. In some cases, even such details as tapped holes may be cast so dependably as to require no further machining. Additional qualities include these:

1. Metal may be distributed so as to give maximum strength at minimum weight.
2. Holes, slots and recesses may be cast to very close fits for moving parts.
3. Very thin sections and a great variety of shapes may be produced, often to configurations that cannot be obtained in a single piece by other processes. Thus, expensive and space-consuming assemblies may be replaced, in many cases, by a single die casting.
4. Inserts of other metallic and non-metallic materials may be cast in place accurately.
5. A wide range of aluminum die casting alloys is available, each with special properties. All are suitable for standard plating and finishing procedures. All may be machined readily.
6. Properly designed dies offer a long service life, offsetting the initial tooling costs.

These features have led to the widespread demand for aluminum die cast parts ranging in size from tiny, fractional-ounce pieces to massive automotive engine blocks and to flange discs 44 inches in diameter. A recently developed die casting machine can produce cast units weighing as much as 65 pounds.

Die casting of precise, interchangeable gears, cams, rotors, bearings, housings and other members permits marketing of household appliances at prices that could not be met with other manufacturing methods. Tremendous quantities of aluminum die castings are used in the automobile industry to improve function, appearance and cost of trim parts, small-motor members, dashboards, window frames, lamp housings, knobs, grilles and even bumpers. The complexities of modern aircraft design are kept within bounds by use of intricate servo-mechanism components, and other operating members, die cast to accuracies measured in thousandths of an inch.

Die castings are made in a semi-automatic process, by injecting molten metal under high pressure into a reusable steel mold. After the casting solidifies it is ejected, and the die is closed to receive another measured quantity of metal.

The basic rules of design for good aluminum die casting are not essentially different from those applying to other casting methods. For example, practice has shown that best die castings result when the part is shaped as simply as possible, when section-thickness changes are gradual, when fillets and radii are of generous size, and so forth.

The casting engineer to whom these principles are familiar will have little difficulty in mastering the further essentials of die casting design.

Among these further rules are the following:

1. Keep weight as low, shape as simple, overall dimensions as small and dimensional tolerances as liberal as the functional requirements permit.
2. Sections should be of minimum practicable thickness and as uniform as possible, with transitions gradual and with sufficient draft to assure removal of castings from the die without distortion.
3. Surfaces to be finished should be accessible, with ejector pins located so as to avoid marring. A slight crown is better than a large, flat area contour.
4. Integrally-cast fastening elements may reduce overall assembly costs. However, unnecessary undercuts, recesses, projections and similar irregularities should be eliminated, as should avoidable coring. When cores are used they should be of substantial strength, shaped for minimum cost.
5. When coring is considered, especially for tapped holes, for very small holes or for holes in thin walls, the cost of coring should be compared carefully with the cost of obtaining these features by machining.
6. When permanent inserts are used, they should be anchored securely in the die, and placed so as to eliminate avoidable interference with die operation.
7. Design for flash removal, and for finish machining where necessary, should avoid unnecessarily deep cuts, and otherwise should maintain minimum cost and scrap loss.
8. Gating and venting should be arranged to permit entry of metal in an orderly manner, so as to reach all parts of the die cavity quickly, with a minimum of spattering, eddying and air entrapment.
9. Design foresight, as to proportions and harmony with mating parts, will contribute to good appearance of assemblies.

The above list necessarily is general and condensed. When these basic rules are followed, along with any further principles that may be recommended by Kaiser Aluminum engineers as applicable to a specific design, the aluminum die casting will offer superior qualities of function, appearance and service.

Selection of the proper aluminum die casting alloy depends upon application and desired features of the end product. Table 3 shows strength characteristics

TABLE 1

OPTIMUM CORED HOLE DEPTHS	
Hole Diameter	Maximum Depth
1/8"	5/16"
5/32"	1/2"
3/16"	5/8"
1/4"	1"
3/8"	1-1/2"
1/2"	2"
5/8"	3-1/8"
3/4"	4-1/2"
1"	6"
Note: For cores larger than 1", diameter/depth ratio is 1:6.	

CONTINUED ON NEXT PAGE ➡

TABLE 2

PRODUCT STANDARD FOR ALUMINUM DIE CASTINGS		
Linear Dimension Tolerances, As Cast	Linear Flatness Tolerances, As Cast	Parting Line Tolerances, As Cast
Basic Tolerance up to 1": ± .004"	Basic Tolerance up to *3": .008"	Projected Area of Casting
		Up to 50 sq. in.: ± .005"
For Each Additional Inch, 1" to 12": ± .0015"	Tolerance For Each Additional *Inch: .003"	50 to 100 sq. in.: ± .008"
For Each Additional Inch over 12": ± .001	*Measured Across Maximum Diameter or Diagonal of Surface	100 to 200 sq. in.: ± .012"
		200 to 300 sq. in.: ± .015"

TABLE 3

Typical Mechanical Properties of Aluminum Die Casting Alloys						
Alloy No.	13	43	85	218	360	380
Tensile Strength in p.s.i.	39,000	30,000	40,000	45,000	44,000	45,000
Yield Strength in p.s.i.	21,000	16,000	24,000	27,000	27,000	26,000
Elongation % in 2"	2.0	9.0	5.0	8.0	3.0	2.0
Mold Filling Capacity	1	3	5	4	1	2
Pressure Tightness	2	3	3	5	1	2
Resistance to Hot Cracking	1	2	4	5	1	2
Machinability	4	5	2	1	3	3
Corrosion Resistance	2	2	5	1	2	4
Anodized Appearance	5	4	2	1	3	3

of representative alloys, together with their relative characteristics in other properties.

For example, if the proposed aluminum die casting were a thin-walled, intricate piece having a smooth, dense surface with good characteristics of strength and corrosion resistance, then alloy #13 or #360 might well be selected. The use of prime metal would insure uniformity and high quality. On the other hand, a heavier and less-detailed die casting might be made from an alloy of the #380 type.

Extensive research has established alloy specifications for all standard purposes. Where product volume permits, Kaiser Aluminum will make available highly specialized die casting alloys.

A variety of decorative and protective finishes are readily applied to aluminum die castings. When effects are desired other than the typically smooth, bright surface, such processes as buffing, brushing and tumbling may be used with great success. On all bare aluminum surfaces, a transparent coating of oxide forms naturally. In some alloys, the protection thus afforded may be increased by anodizing. Paints, varnishes and lacquers adhere firmly to aluminum, with a minimum of preparation. Aluminum surfaces offer the best known base for adhesive-sheet and decalcomania-type materials.

Thus, the manufacturing convenience and low unit cost of aluminum die castings production are complemented by similarly versatile and inexpensive finish processing.

The engineering advisory services of Kaiser Aluminum are available without obligation to manufacturers wishing to take full advantage of the desirable properties of aluminum die casting.

Prompt attention to inquiries regarding new designs, or the improvement of existing designs, may be obtained through the Kaiser Aluminum sales office listed in your telephone directory, or through any of our distributors. Kaiser Aluminum & Chemical Sales, Inc., *General Sales Office*, Palmolive Building, 919 North Michigan Avenue, Chicago 11, Illinois; *Executive Office*, 7772 Kaiser Building, 1924 Broadway, Oakland 12, California.

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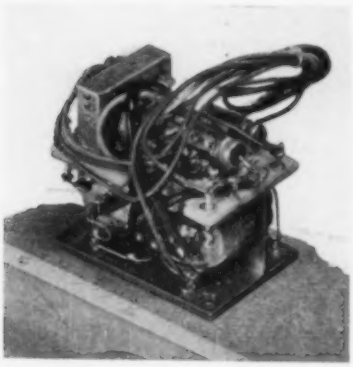
located warning device or, with suitable relays to operate preventive interlocks. This instrument operates on a pressure differential of less than ½ psi.

Standard models are offered for ⅜ in. pipe and tube connections; ¼ and ½ in. connections available on request. It is stated that this indicator is suitable for installation on a variety of small, low capacity circulating systems such as vent, lube and cooling lines. Gems Co., Newington, Conn.

For more information—
Circle 81, inside back cover



Transistor-Equipped Servo Amplifier

This servo amplifier assembly measures 1½ x 1½ x 1 in. and provides a power gain of 10^5:1. No output transformer is necessary, according to the maker, because the amplifier works directly into a size 10 servo motor, which has center tap control winding. Control phase impedance of the servo is 250 ohm effective resistance when tuned with a 2 mf capacitor.

Amplifier rating is 1 w at 71 C ambient operating temperature, range — 55 C to 71 C and voltage gain approximately 300:1. John Oster Mfg. Co., Racine, Wis.

For more information—
Circle 82, inside back cover

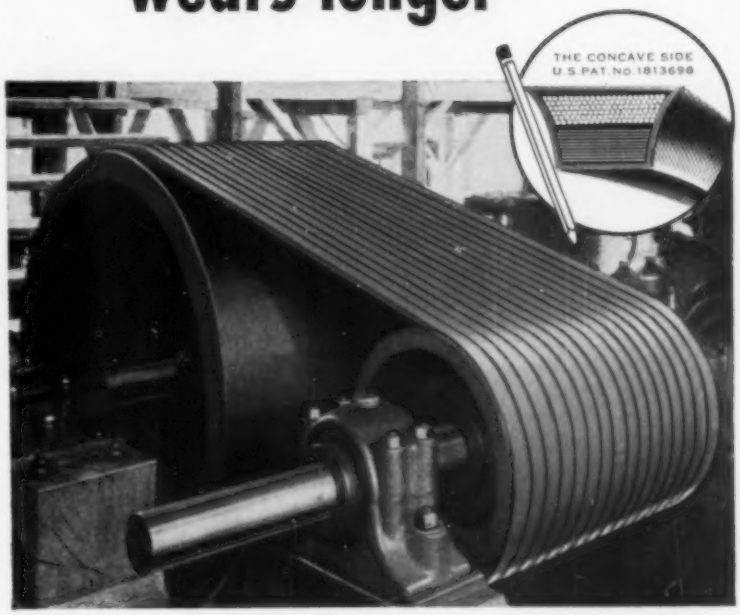
Test Jack Eyelets

An insulated miniature test jack with an integral molded eyelet has been designed to providing points of check for circuitry on equipment front panel, chassis or other accessible check points. The jack requires only a 0.261 in. mounting hole.

The head is ⅜ in. dia and it takes

(Continued on page 284)

Why a V-Belt with CONCAVE SIDES wears longer



It is easy to demonstrate to yourself why the concave sides (Fig. 1) of the Gates belt greatly lengthen belt life.

Simply bend a Gates belt and feel the sides. Notice how these precisely engineered concave sides *fill out* on the bend and *become straight*. Thus a Gates belt grips the sheave groove evenly (Fig. 1-A) and wear is distributed uniformly across each side of the belt. That means longer belt life; lower costs.

Make the same test with a straight-sided belt (Fig. 2) and see what happens. The sides bulge out on the bend (Fig. 2-A) concentrating the wear at points shown by arrows.

To assure longer wear and keep belt costs down, specify the V-belt with Concave sides—Gates Vulco Rope . . . readily available from nearby distributor stocks. The Gates Rubber Company, Denver, Colorado—*World's Largest Maker of V-Belts.*

There are Gates Engineering Offices and Distributor Stocks in all industrial centers of the United States and Canada, and in 70 other countries throughout the world.

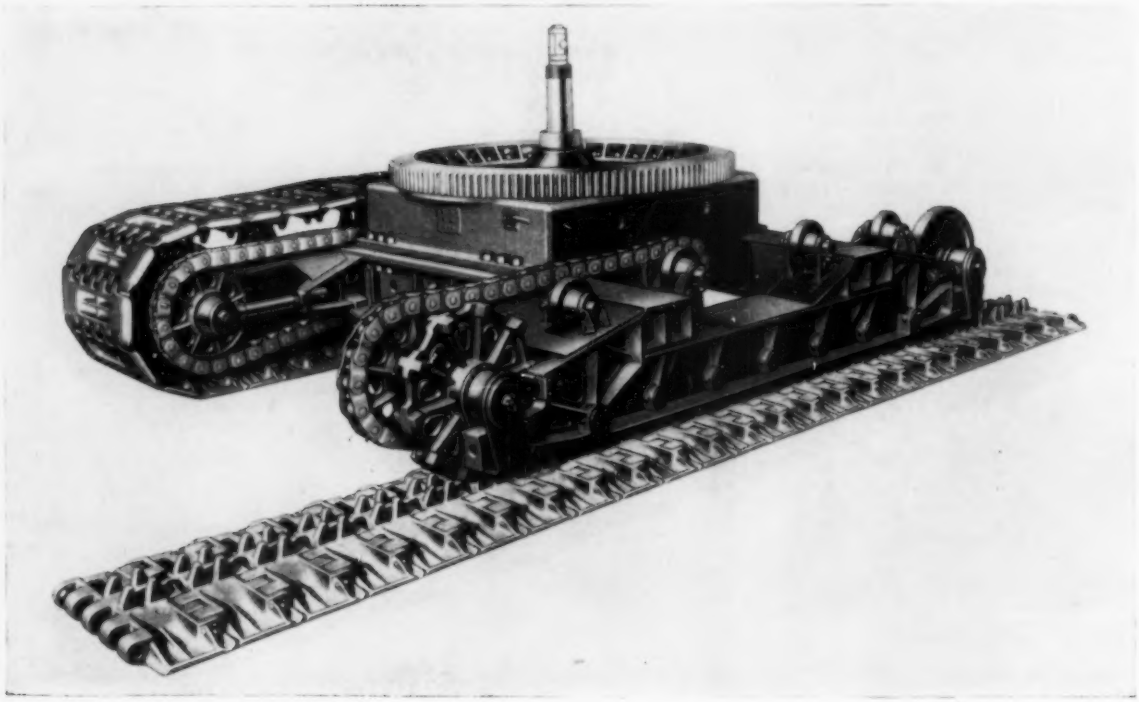
TPA 90

Gates VULCO ROPE Drives

Thew Shovel says:

"JEFFREY CHAIN suits our rigid requirements to a T*"

*T for Thew, of course.



Preparing a shovel crawler for final assembly, showing Jeffrey STR drive chain.

THE BEST evidence of the quality of a product is the company it keeps. Jeffrey is proud that its chain is selected for powering drives on many power shovels. The quality of the product makes the difference.

Whether your requirements are for power transmission or conveyor service, there's a Jeffrey chain best suited for your purpose. Our engineers will help you select the chain you need.

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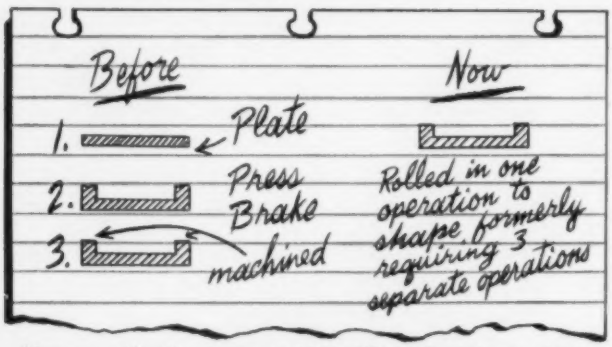

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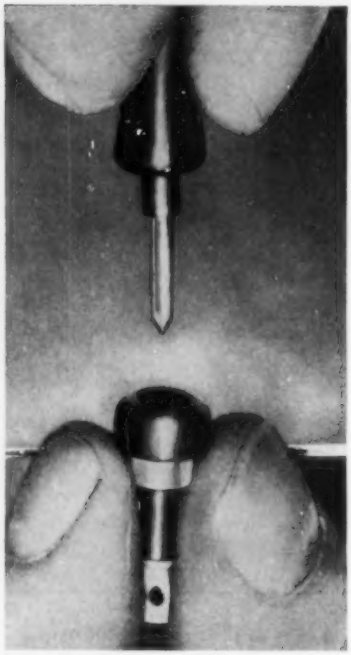

less than ⅛ in. behind panel. Contact insulation is nylon, rated for 3.5 kv, dc, with jack mounted on metal panel, test prod inserted. Ambient temperature range is from −30 C to 105 C. Dept. TJ 44, Alden Products Co., Brockton, Mass.

For more information—
Circle 83, inside back cover

Electrical Timing Meters

A line of a-c meters for 120, 240 and 480 v, 25, 50 and 60 cps, is available in 10,000 hr (showing 1/10 hr) and in 100,000 hr models. The mechanism is enclosed and sealed against dust, moisture and other foreign matter. Powered by a synchronous motor. John W. Hobbs Corp., Springfield, Ill.

For more information—
Circle 84, inside back cover

Automatic Regulator-Lubricator

This filter-lubricator-regulator assembly designed to remove foreign matter and condensation from the air supply. A porous bronze filter element is available in three degrees of filtration, 20, 40, and 90 microns. Supplied with transparent bowl for pressures up to 150 psi, 120 F. Filter

(Continued on page 287)

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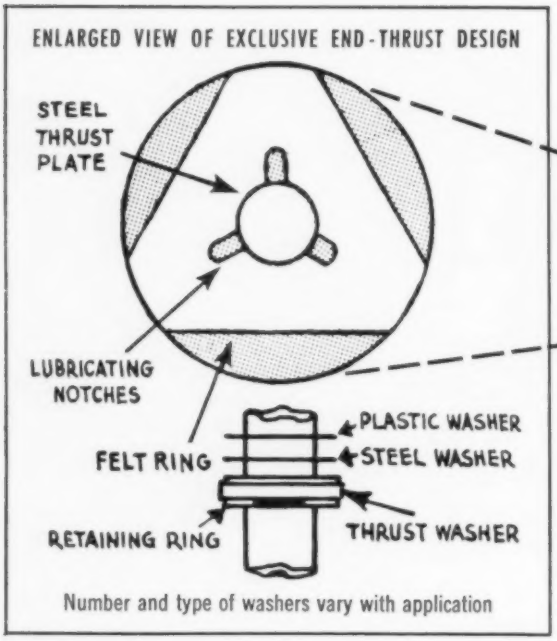
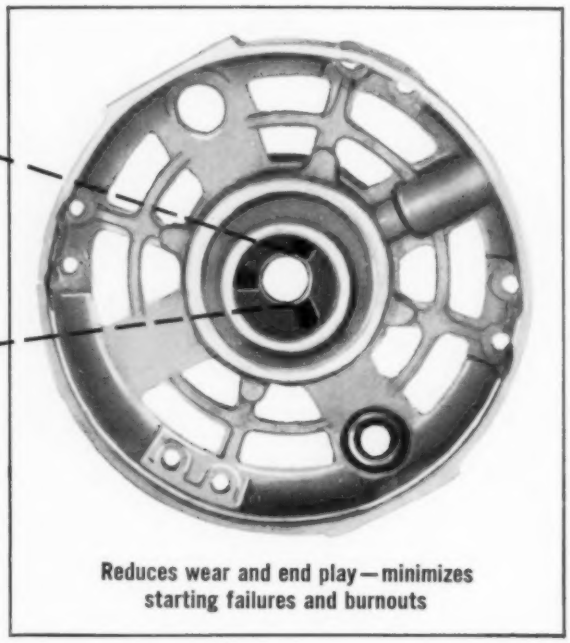
Emerson-Electric engineering highlights

New, exclusive end-thrust design for vertical and shaded-pole, sleeve-bearing motors



Number and type of washers vary with application



Reduces wear and end play—minimizes starting failures and burnouts

Smooth, quiet operation and longer motor life result from the exclusive end-thrust design incorporated in Emerson-Electric sleeve-bearing motors, for thrust applications.

The face of the new-design steel thrust plate is provided with three slotted lubricating notches. In operation, the lubricant-saturated felt ring "bellies" up through the slots. This causes the felt-ring lubricant to be carried to the thrust surface. Continuous lubrication is thus assured—longer, noiseless operating life results.

This exclusive end-thrust feature is another Emerson-Electric engineering highlight. It illustrates once more the reason why Emerson-Electric motors have been the wise choice for power-driven equipment for more than 60 years.

Call on Emerson-Electric motor-drive specialists

The combined experience of Emerson Electric motor-drive specialists is available to designers and manufacturers of motor-driven appliances. This valuable "assist" from Emerson Electric can be profitably applied, whether you're designing or redesigning for performance and sales. Write for Bulletin No. M40. THE EMERSON ELECTRIC MFG. CO., St. Louis 21, Mo.

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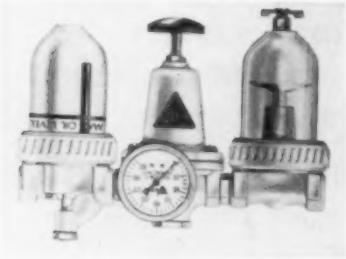
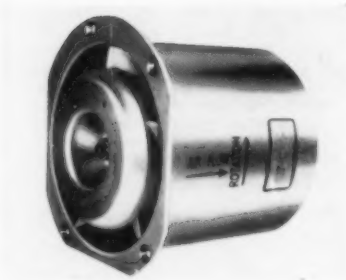


available in sizes ¼, ⅜, and ½ in., female pipe connections. Watts Regulator Co., 10 Embankment St., Lawrence, Mass.

For more information—
Circle 85, inside back cover



Blower Compensates for Low Air Tensity

A fan-blower unit designed for airborne applications compensates for low air density by increasing blower speeds. The blower will provide 8000 rpm, with 210 cfm at 2 in. back pressure, at sea level. At 60,000 ft, blower speed is increased to 11,000 rpm.

This device has a vane axial fan with a ⅛ hp a-c motor, operating at 115 v, 2.5 amp, 400 cps. Induction Motors Corp., 570 Main St., Westbury, N. Y.

For more information—
Circle 86, inside back cover

Condensation or Temperature Control

On components such as the heating platens of a hydraulic molding press, this condensation control or blow down timer helps to establish uniform temperatures and to insure proper action of the trap. Constructed within an air tight JIC case, this unit is adjustable by means of two selector switches. One switch will determine the interval between slow down. The

(Continued on page 289)

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"TEMPBRAID" cables come in 2 to 30 conductors in sizes 12 to 30 AWG. These cables are available with Teflon insulated conductors with a 5 mil (.005") wall, or the conventional Type E and EE insulated conductors that conform to MIL-W-16878, and a combination of coaxial cables.

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A flat harness woven of tin/lead or silver plated copper. This harness eliminates lacing cord, binding posts, cable clamps.

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*DuPont's Trade Name for POLYTETRAFLUOROETHYLENE

This new Dodge No. 8 Torque Arm Reducer with a capacity of 60 h.p. at 100 r.p.m. utilizes a Formsprag Series 50 Backstop Clutch. Bob Haas (left), Formsprag District Manager discusses its operation with Alec Bodle (right), Chief Engineer, and David Firth, Vice President, Engineering of Dodge Manufacturing Corporation.

"Sure, we use Formsprag Clutches to insure maximum precision, long life . . . here's why . . ."

"Dodge Torque-Arm Speed Reducers are built for efficiency up to 97%—as demonstrated in thousands of installations.

"Precision preformance like this means that every component part must perform with extreme accuracy—and be able to take it!

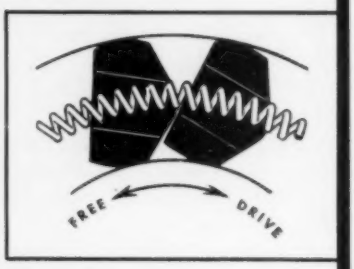
"That's why Formsprag Clutches are used for built-in backstops in our speed reducers. Not only do they offer maximum torque in a minimum area, but they've proven their 'long-life' capabilities in thousands of diverse applications."

Dodge is just one of the myriad of industrial manufacturers taking advantage of these Formsprag Clutch design features:

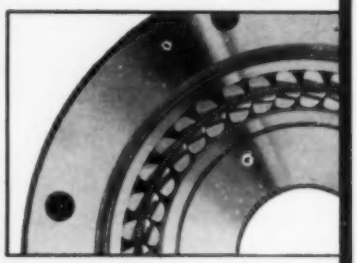
- HIGHER TORQUE CAPACITY
- LONGER LIFE
- INTERNAL SIMPLICITY
- NO MEASURABLE BACKLASH
- EXCEPTIONALLY LOW MAINTENANCE

Why not put Formsprag's experienced engineers to work for the betterment of your product? Write today for comprehensive literature.

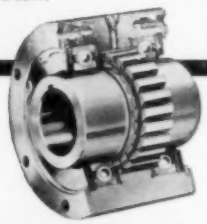
HOW FORMSPRAG'S SIMPLE PRECISION DESIGN WORKS FOR YOU:



Sprags used in Formsprag Clutches are highly developed, precision wedges of hardened alloy steel. Due to the sprag's design, an unusually high amount of torque is delivered from one concentric race to the other. When torque is applied, the sprags are instantaneously engaged. When torque is removed, the sprags release instantaneously.



Basic construction of the Formsprag Clutch is simple. A full complement of sprags is inserted between inner and outer concentric races. Contact with both race surfaces is maintained by energizing springs. Formsprag construction allows more sprags to be inserted in a smaller area than other clutch designs. Result: greater torque capacity in a smaller clutch.



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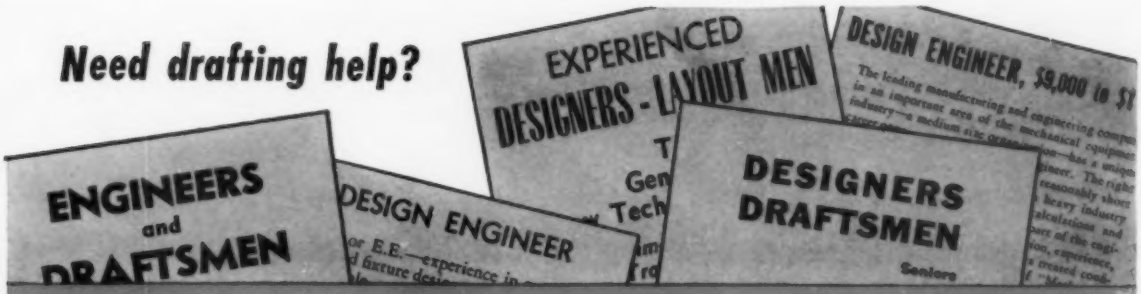

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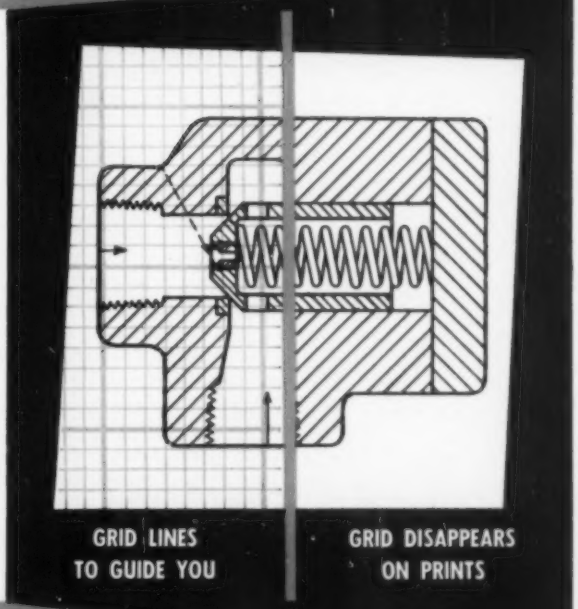

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It is adapted to use as expansion chambers, seals for packless valves, rotating shaft seals, pumping elements, pressure measuring elements, flexible piping sections, pulsing elements, mechanical shields, thermal expansion elements, flexible hermetic seals, vibration dampeners, piping swing joints, flexible couplings and many other equipment and instrument applications in the chemical, atomic energy, food, pharmaceutical and biological fields.

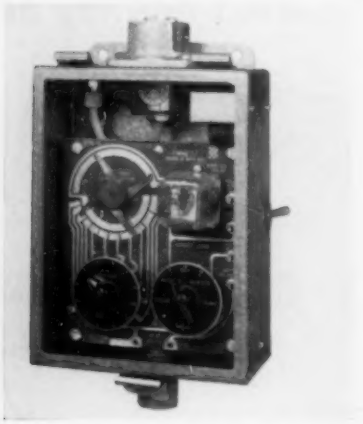
U. S. G. Teflon Bellows have been custom made in sizes from ½" ID to 18" ID, with few convolutions or a great many, with a wide variation in convolution depth and wall thickness provided for either extremely sensitive or rugged industrial service.

Tell us your design problem and we will recommend the Teflon Bellows best suited to your requirements.

U S G BELMONT

UNITED STATES GASKET COMPANY
CAMDEN 1, NEW JERSEY

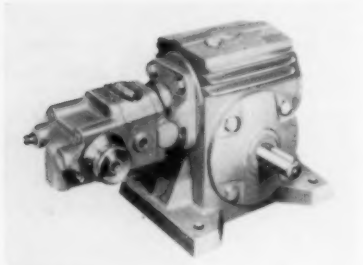
*du Pont's trademark for its tetrafluoroethylene resin.



other switch will determine the length of time that this action takes place, such as 4 through 14 sec.

The selector switch accomplishing this connects through printed circuitry to contact pads of varying length, so that the rotation of the contact arms on a small synchronous motor will be energized for the number of seconds it takes the contact arm to traverse the pad which has been selected to energize the output of the control. Emmett Machine & Mfg. Inc., 445 E. Turkeyfoot Lake Road, Akron 19, Ohio

For more information—
Circle 87, inside back cover



Fluid Motor-Speed Reducer

This combination unit combines a slow output rpm with a torque multiplication. The fluid motor is equipped with a built-in relief valve that allows maximum torque input to the speed reducer and prevents overloading.

Typical of its uses are conveyor drives where variable speed is required, any device requiring variable speed and relatively low output and feeding attachments. Speed reducers are available in a range of ratios, with speed control valves to handle 0 to 2 gpm.

(Continued on page 292)

300 one-ton precision forgings? Standard Steel makes them—fast!

Whatever your requirements are for forgings, large or small, we can make them to strictest specifications—and make them fast.

On a recent job for R. Hoe and Company, Inc., of New York, we made 300 one-ton cylinder forgings for printing presses. They were delivered on schedule, and measured up completely to the rigid specifications required for precision printing presses.

Hoe has standardized on Standard Steel cylinder forgings because:

- Cylinders are forged close to final tolerances, so expensive machining time is greatly reduced.
- Uniform grain structure of forged steel cylinders provides strength to hold the frequently-changed printing plates on the fast-revolving cylinders.
- Dimensional stability of forged steel cylinders assures that press operation will not be jeopardized by metal distortion.

Standard Steel Works can also furnish you with shafts, wheels, gear blanks, rings, flanges and special shapes. Next time you need forgings of any kind, and need them on time, get our quotation first. For your copy of bulletin 10,000, write Dept. 8635, Standard Steel Works Division, BLH Corporation, Burnham, Penna.

BALDWIN BLH LIMA-HAMILTON

STANDARD STEEL WORKS DIVISION
BALDWIN-LIMA-HAMILTON

DIVISIONS: Austin-Western • Eddystone • Hamilton • Electronics & Instrumentation • Lima • Madsen • Loewy-Hydropress • Pelton • Standard Steel Works

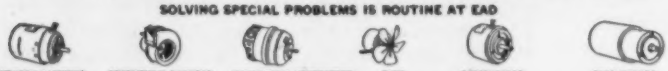
Here is the most compact centrifugal blower unit made . . . EAD's high-velocity subminiature centrifugal blower is only 2⅛" long, weighs only 6 ounces, yet it can move 13 cfm of air at a velocity of 3,000 feet per minute—and the volume holds up at high static pressures. It is driven by EAD's new one-inch diameter motor. The metal blower housing can be rotated to any position desired for maximum efficiency in cooling radar equipment, amplifier units, transmitter equipment, oscillators, and in other applications where high temperatures in confined areas demand miniaturized blowers with the highest possible performance characteristics. EAD's subminiature blower units meet all applicable MIL specification, and low temperature rise makes them suitable for high altitude and high ambient temperature operation.

CFM	13 @ 0" SP 10 @ 1.0" SP	7 @ 0" SP 5 @ .2" SP
MAX. SP.	2.5	0.6
RPM	20,000	11,000
AMPS	0.1	0.06
WATTS	10.0	6.0
CAPACITOR Mfd/Volts	0.25/220	0.1/220
WEIGHT (OUNCES)	6	6
MODEL NO.	B2GOU-C	B2HOU-C

Modifications of standard models or completely new designs can be engineered to meet your special cooling needs. Write for complete information.

EASTERN AIR DEVICES, INC.

SOLVING SPECIAL PROBLEMS IS ROUTINE AT EAD



381 CENTRAL AVENUE • DOVER, NEW HAMPSHIRE

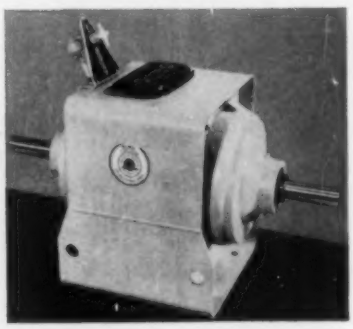
0 to 4 gpm and 0 to 6 gpm. The fluid motors have gear widths of ½, ¾, 1 in. John S. Barnes Corp., Rockford, Ill.

For more information—
Circle 88, inside back cover

Oscilloscope Probe and Viewing Hood

A fixed-ratio test probe which permits observation of signals in circuits with high source impedance without loading the circuit, has been made available together with a 3-in. rubber viewing hood. Offering 10 megohm input impedance, the probe is a general purpose unit, which has a frequency range from dc to 10 megacycle per sec. The attenuation ratio is 10:1. The viewing hood is furnished with a mounting clip for fastening to the panel bezel of an oscillograph. Allen B. Du Mont Laboratories, Inc., 760 Bloomfield Ave., Clifton, N. J.

For more information—
Circle 89, inside back cover



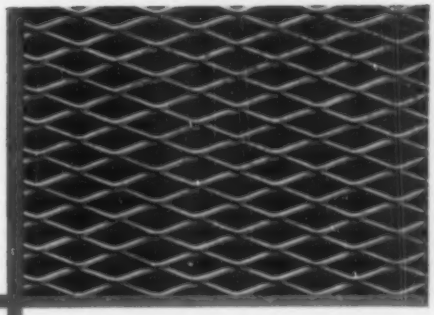
Adjustable Fluid Drive

Adjustable speed fluid drives for 1 through 25 hp applications are said to be suitable for installations where automatic speed adjustment, and positively uniform accuracy of repeat speed settings are prime considerations. These units can be used with a conventional single-speed electric drive motor to provide adjustable, stepless speed control. Speed adjustment can be manual or automatic. Where a two directional motor is used, the fluid drive and load can be reversed while in motion by merely changing motor rotation.

Output shaft speed is altered during operation by varying the amount of oil in the fluid drive's working circuit.

(Continued on page 294)

Handsome, functional MINIMESH ⇨ makes good products better



Minimesh grille protects speaker, transmits sound, adds beauty in new coin-operated phonograph by J. P. Seeburg Corp., Chicago.

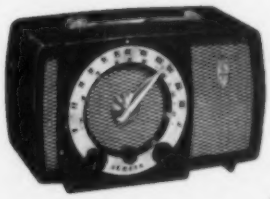
Because it combines beauty and utility — at low cost, Penmetal Minimesh is widely used for decorative purposes and for guards or grilles on stoves, heaters, radios, phonographs, etc. Three famous products, which have been improved with Minimesh, are shown.

Minimesh is small mesh ($^3/_{16}$") expanded metal, and like the larger meshes, is sheet metal which has been slit and expanded up to five times its original width. 80% lighter than solid sheet of the same dimensions, the diamond truss pattern adds rigidity and strength.

The openings in Minimesh permit passage of light, heat, air and sound. Comes in standard or flattened form. Can be cut, shaped or welded to suit design requirements.

Put Minimesh to work for you. Write for new catalog 510-EM, which gives sizes, weights and dimensions.

PENN METAL COMPANY, INC.
General Sales Office: 205 East 42nd Street
New York 17, N. Y.
Plant: Parkersburg, W. Va.
District Sales Offices: Boston, New York, Philadelphia, Pittsburgh, Chicago, Detroit, St. Louis, Dallas, Little Rock, Seattle, San Francisco, Los Angeles, Parkersburg



ABOVE — Zenith Radio Corp., Chicago, incorporates extensive Minimesh grillework in this radio set.

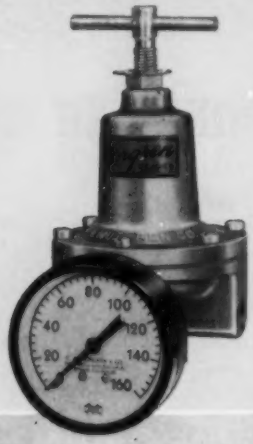
RIGHT — Gas heater by Temco, Inc., Nashville, Tenn. — one in a famous line recently redesigned with Minimesh to bring modern styling to the gas heating field. Open mesh grilles deliver heat.

METAL MARK
Penmetal
1869
OF QUALITY

PM-100

NORGREN
AIR PRESSURE REGULATORS

Accurate, Dependable Control of Air Pressure



There's a Norgren Regulator for Every Air Regulation Need.

All air-operated equipment is designed to operate most efficiently at one specified air pressure. Pressures in excess of this specified pressure result in greater wear, more down-time, higher maintenance cost and waste of air. You can select a Norgren Regulator that will provide the desired pressure at all times, holding it constant even though the line pressure or rate of flow may vary.

How Norgren Regulators Provide Accurate, Trouble-Free Service...

1. PRECISION CONSTRUCTION

Norgren Pressure Regulators are precision built throughout to provide accurate pressure regulation under the most rugged conditions.

2. PRESSURE KEPT CONSTANT

Norgren Pressure Regulators respond quickly to sudden demands for greater air volume without an excessive momentary pressure drop.

3. EFFICIENT OPERATION

A baffle plate and siphon tube permits greater air flow with less pressure drop and protects the diaphragm against sudden pressure surges and chatter.

4. LONG-WEARING DIAPHRAGM

The diaphragm in Norgren Pressure Regulators is made of oil-resistant synthetic rubber reinforced with nylon fabric.

5. RELIEVING FEATURE

The built-in relieving feature available on all models safeguards connected equipment against damage through pressure surges—permits downward adjustment of pressure without auxiliary "bleeding" of line.

6. EASY TO INSTALL

Pipe connections are straight through for easy installation. In addition, most models can be completely dismantled without removing them from the air line.

Without obligation, learn how Norgren Pressure Regulators can reduce costs in your plant. Call your nearby Norgren Representative listed in your telephone directory, or **WRITE THE FACTORY FOR NEW NO. 700 CATALOG.**

C.A. Norgren CO.

3428 So. Elati St., Englewood, Colo.

Wherever Air is Used in Industry

NEARLY 400 STANDARD MODELS

NORGREN AIR PRESSURE REGULATORS, RELIEVING

Relieving feature provides added protection against excessive pressure build-up. Permits downward adjustment of pressure without "bleeding" of line. Maximum allowable primary pressure is 400 psi; adjustable delivery pressure is 2 to 250 psi. Pipe sizes—⅛" to 1" inclusive. Series 2AX.

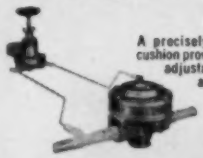
NORGREN AIR PRESSURE REGULATORS, STANDARD

Maximum allowable primary pressure is 400 psi; adjustable delivery pressure is 2 to 250 psi. Pipe sizes—⅛" to 1" inclusive. Series 2A.

NORGREN AIR PRESSURE REGULATORS, PRECISION

For precise control of air pressure in the range of 0 to 2 cfm. Specially suited for use with air-controlled instruments. Maximum allowable primary pressure is 400 psi; adjustable delivery pressure is 1 to 30 psi. Relieving type. Pipe size—¼". Series 11,400.

NORGREN AIR PRESSURE REGULATORS, PILOT-CONTROLLED



A precisely controlled air cushion provides an extended adjustable range, more accurate pressure regulation, increased capacity in cfm. Maximum allowable primary pressure is 400 psi; adjustable delivery pressure is 2 to 120 psi. Pipe sizes—⅛", ¼", ½". Series 20AA.

Working oil level is controlled by a sliding scoop tube mechanism which is readily adapted to any known method of automatic actuation. These fluid drives are available in four sizes, for use with motor ratings between 1 and 25 hp at operating speeds of 1200 and 1800 rpm, plus 3600 rpm for Models 55 and 76 only. Speed reductions up to 4:1 are permitted for constant torque loads and 5:1 for variable torque loads. American Blower Corp., Detroit 32, Mich.

For more information—
Circle 90, inside back cover

Variable Pitch Motor Pulleys

These motor pulleys, designed for use with a B section V-belt are made of non-interlocking, non-serrated machined cast iron discs that are smooth all the way down to the minimum pitch diameter. The pulley has oil impregnated bushings on the pulley shaft and requires no greasing. The pulleys are rated at ¾ hp at 1750 rpm with 2.8:1 speed variation and 1 hp at 1750 rpm with 2.3:1 speed variation, respectively. Dimensions are 3½ x 5 in. dia., 4⅜ x 5¾ in dia. Both pulleys are available in stock bores of ⅝, ¾ and ⅞ in. Gerbing Mfg. Corp., 11800 Milwaukee Ave., Northbrook, Ill.

For more information—
Circle 91, insde back cover

Hydraulic Air Coolers

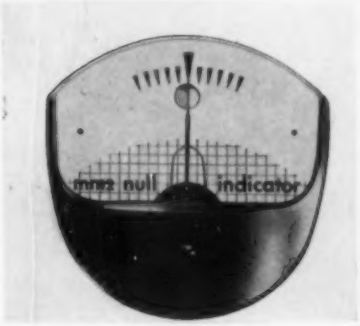
A line of air type and water type oil coolers for industrial hydraulic systems are available in single unit

(Continued on page 295)

sizes for oil flows up to 100 gpm and for continuous power removals up to 37 hp (based on 85 F entering water temperature). Two smaller coolers of equal size can be used in parallel. Maximum recommended working pressure is 75 psi for both the oil and the water sides.

The coolers are available in single unit sizes for oil flows up to 70 gpm and for continuous power removals up to 13.2 hp, based on 100 F average ambient temperature. Vickers Inc., Detroit 32, Michigan

For more information—
Circle 92, inside back cover



Null Indicator

A 2½ in. null indicator is available in three different sensitivities, with full scale current ratings of 100, 200 and 500 ua, respectively. Marion Electrical Instrument Co., Grenier Field, Manchester, N. H.

For more information—
Circle 93, inside back cover

Sealed Potentiometers

A line of encapsulated potentiometers is available in both wire-wound and composition-element types. Clarostat Mfg. Co., Inc., Dover, N. H.

For more information—
Circle 94, inside back cover

A Universal Cylinder Mountings

These mountings are said to eliminate problems due to misalignment between cylinders and their loads. They are available in two forms: a hinge-mount cylinder with universal mounting brackets at each end and a cylinder with universal trunnion and

(Continued on page 298)

Norgren RELIEF VALVES
Protect Your Air Equipment from Excessive Pressure Build-Up

DIAPHRAGM TYPE VALVES

Model 62AX2
¼" pipe size

AUTOMATIC PROTECTION
Norgren Relief Valves automatically protect fluid lines and connected equipment from damage resulting from excessive pressure build-up, and provide controlled operation of fluid recirculating systems.

EASILY ADJUSTABLE—
Norgren Relief Valves can be set to relieve automatically at a specified pressure. ⅛", ¼", ⅜", ½" pipe sizes available with maximum relief settings at 15 psi, 50 psi, 75 psi, 125 psi, or 250 psi; ¾" and 1" sizes available for maximum relief settings at 15 psi, 50 psi, 75 psi or 125 psi. Pressure settings remain constant.

RUGGED CONSTRUCTION
The diaphragm is made of strong, tough, nylon-reinforced synthetic rubber and its large area assures you of positive valve action and close control of operating pressure.

POP SAFETY VALVES

Norgren Pop Safety Valves prevent the build-up of dangerous, excessive pressures on air tanks. When the tank pressure exceeds the valve's relief pressure setting, the valve automatically pops open and rapidly releases air from the tank. When the tank pressure returns to a safe load, the valve automatically closes. Performance of these valves is not affected by vibration. ⅛", ¼", ⅜", ½" pipe sizes.

Model 1003
⅜" pipe size

LOW FLOW RELIEF VALVES

Small, inexpensive, low capacity valves suited for a wide variety of uses—for relieving low-volume air compressors, as automatic relief of secondary pressure on cylinder gas regulators, as a small water relief valve, and similar uses requiring relief at low rates of flow. ⅛" and ¼" pipe sizes.

Model 61A2
¼" pipe size

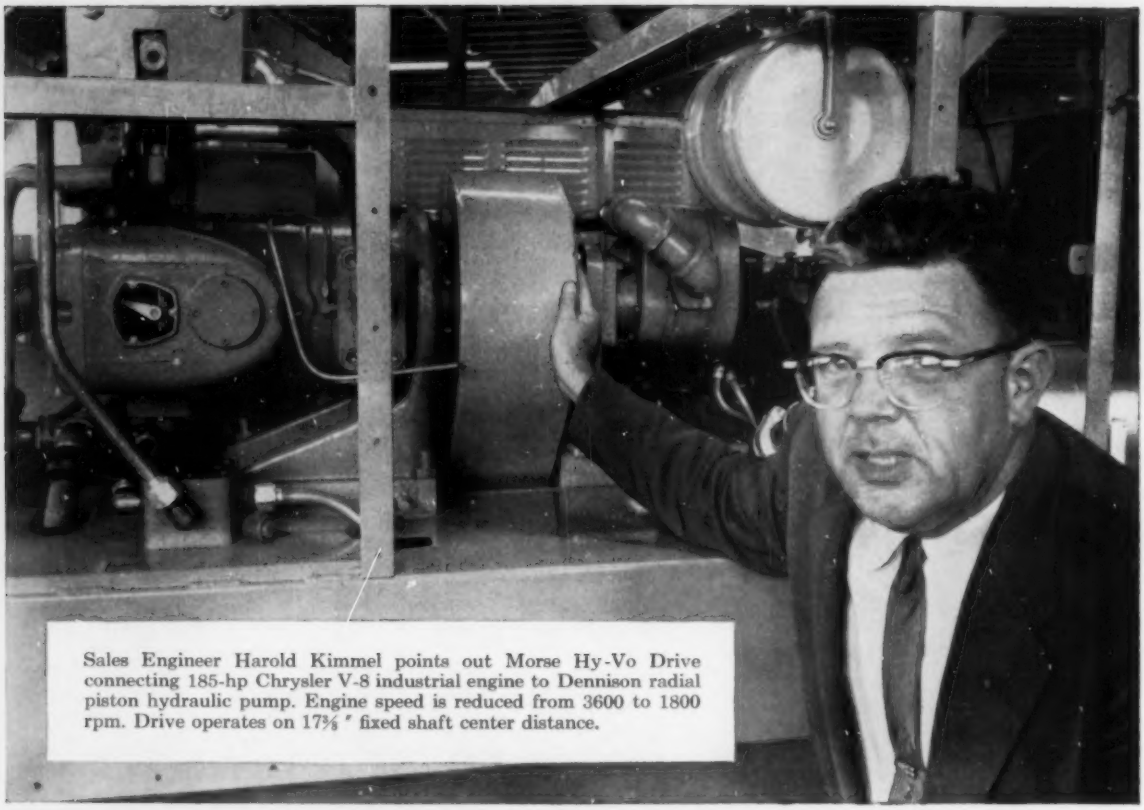
Without obligation, learn how Norgren Relief Valves can reduce costs in your plant. Call your nearby Norgren Representative listed in your telephone directory . . .

or WRITE THE FACTORY FOR NEW No. 700 CATALOG.
3428 So. Elati St., Englewood, Colo.

C.A. Norgren CO.

Wherever Air is Used in Industry

Morse HY-VO Chain offers designers high-hp capacity; space and cost savings



Sales Engineer Harold Kimmel points out Morse Hy-Vo Drive connecting 185-hp Chrysler V-8 industrial engine to Dennison radial piston hydraulic pump. Engine speed is reduced from 3600 to 1800 rpm. Drive operates on 17⅜″ fixed shaft center distance.

Morse Hy-Vo's exclusive rocker-joint design and freedom from chordal action reduce wear and friction, eliminate stretch, and permit fixed shaft centers.

Narrow Hy-Vo Drive transmits power smoothly, efficiently at 6,250 fpm in new jet-engine starter.

In building the Pre-Flight Equipment Jet Hydrostarter, the basic design problem was to find a compact, efficient method of transmitting power from the primary motor to the pumps which actuate the hydraulic starting motor. In addition to providing a 50% speed reduction, the power transmission unit had to withstand reactive shock loads up to 100 hp, occurring each time the jet fuel is ignited.

The solution was a stock Morse Hy-Vo Drive only 3″ wide. This compact unit proved to be the most economical method of transmitting the required HP at high speed in the limited space.

Hy-Vo Drives are built for maximum-load-carrying capacity per inch of width at both high and low speeds. They provide smooth, efficient power transmission at speeds up to 8500 fpm.

Call or write for complete information and engineering assistance on Morse Hy-Vo Drives. MORSE CHAIN CO., A BORG-WARNER INDUSTRY, ITHACA, N. Y.

MORSE MORSE BW BORG-WARNER® **POWER TRANSMISSION PRODUCTS**

®Trademark

Fosbond zinc-phosphating Process made EVEN BETTER with new, improved

actidip

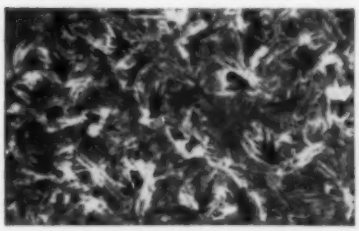
- **Gives you one-coat painting**
- **Lowers effective phosphate weight as much as 70%**
- **Reduces maintenance cost by cutting down sludge**
- **Gives more and better surface activation at reduced cost**

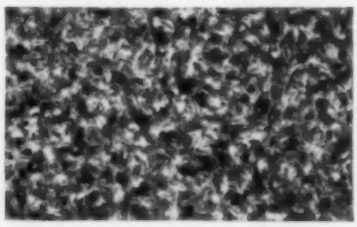
Painted metal surfaces (on automobile bodies, home appliances, and other products) enjoy greatest corrosion-resistance when protected beforehand with Pennsalt Fosbond® coatings. Now, a pre-Fosbond bath with ACTIDIP® brings about even greater crystal refinement, prevents powdering, allows finishing with a single coat of paint. New, improved ACTIDIP, used as a pre-rinse, reduces subsequent zinc phosphate coating weights up to 70% over those coatings applied without surface treatment. As an ingredient in Pennsalt Activated Cleaners, ACTIDIP activates during the pre-cleaning cycle and reduces zinc phosphate coating weights by as much as half.

With recent improvements in formulation, ACTIDIP makes your job easier, boosts your coating quality: (1) Free-flowing and non-caking, *new* ACTIDIP dissolves more easily, speeds tank charging; (2) ACTIDIP has greater stability, will not lose its superior activating power at higher cleaning temperatures; (3) ACTIDIP, alone or in a Pennsalt Activated Cleaner, reduces sludge and maintenance costs in the phosphating bath.

Two convenient forms. New, improved ACTIDIP comes to you in a choice of two forms: (1) Super ACTIDIP Powder for use in its own activating bath between cleaning and phosphating; (2) Pennsalt Activated Alkaline Cleaners for soak or spray cycles—cleaning and activation in one bath. Either form you choose gives your organic finish a better start towards corrosion-resistance, long-lived luster, and lower cost.

Find out why Pennsalt's Fosbond Process means the best in phosphate coatings, and how ACTIDIP can bring you better finishing at lower costs. Ask your Pennsalt man or write Metal Processing Dept. 278, Pennsylvania Salt Manufacturing Company. East: Three Penn Center Plaza, Philadelphia 2, Pa.; West: 2020 Milvia Street, Berkeley 4, Calif. In Canada: Pennsalt Chemicals of Canada, Hamilton, Ontario.





Sensational reduction in phosphate-coating weight is shown by these photomicrographs (enlarged 84 times). Untreated panel (left) requires 1006 mg./sq. ft. for adequate phosphate protection, while ACTIDIP-treated panel (right) requires only 277 mg./sq. ft. for effective coverage.

Pennsalt Chemicals

Metal Cleaners • Phosphate Coatings • Cold-Working Lubricants

A BETTER START FOR YOUR FINISH

...chances are
PRESTOLE HAS IT!

PRESTOLE Single or Multiple impression fasteners, having a variety of sizes and shapes, can be used to speed up, simplify and add greater strength to attachments involving one or more hole locations.

Typical applications include hinges, baffles, switch boxes and assemblies, radiator grilles and similar specialized components requiring one or more hole locations for regular or blind fastening.

These PRESTOLE fasteners, featuring the outstanding PRESTOLE impression, can be made to special specifications. In most cases new tooling is not required. Therefore, quantity delivery to your production is possible immediately, and costs are reduced.

PRESTOLE is solving fastening problems at an average rate of 15 per week. Over the years, PRESTOLE engineers have solved thousands of problems involving fasteners used in automobiles, refrigerators, stoves, radios, television sets and similar products of daily use by the public.

Yes, chances are PRESTOLE HAS IT!

Prestole
CORPORATION
1305 MIAMI ST., TOLEDO 5, OHIO

SEND ENGINEERING APPLICATION DATA...

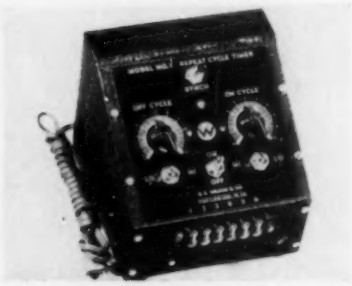
TO:
Name_____
Company_____
Street_____
City_____ Zone____ State_____

FOR:
Application_____

universal mounting bracket for the rod end.

Common applications for cylinders with universal mountings include the operation of hopper gates, elements rotating about shafts such as gear segments and levers, and objects moving on wheels or tracks such as trucks or transfer tables. They also compensate for deflection and misalignment where cylinders are connected to structures that are riveted, bolted or welded together. Hanna Engineering Works, 1765 N. Elston Ave., Chicago 22, Ill.

For more information—
Circle 95, inside back cover



Repeat Cycle Electronic Timer

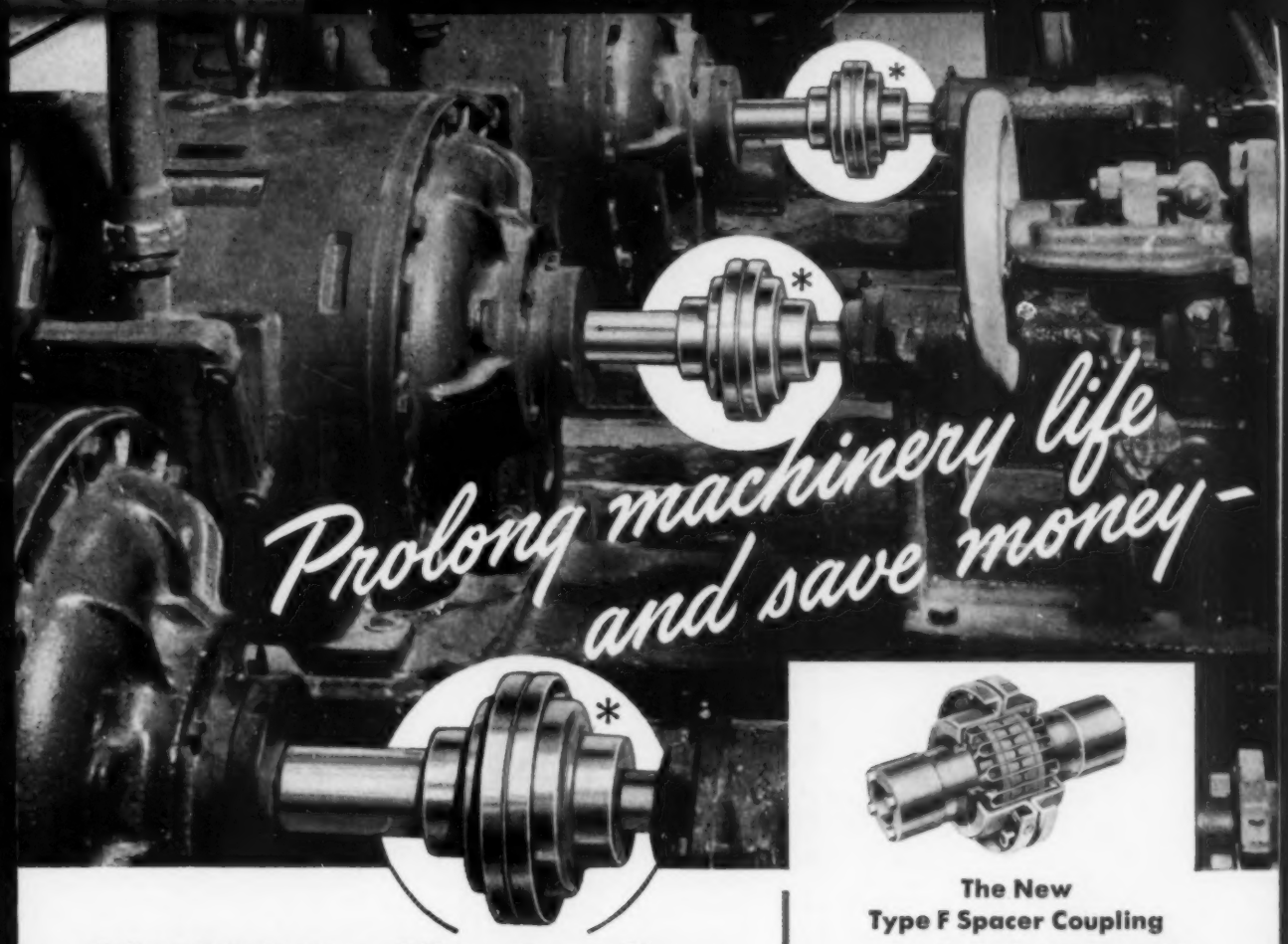
A fully enclosed electronic timer providing adjustable time intervals from 0.1 to 200 sec is said to be suitable for a range of industrial and laboratory controls. Repeatability of 1 per cent or better is achieved under normal operating conditions. Power supply required is 105-120 v, ac. G. C. Wilson & Co., 1915 Eighth Ave., Huntington, W. Va.

For more information—
Circle 96, inside back cover

Portable Electric Meters

These wattmeters, voltmeters and milliameters should be of particular interest in aircraft electronics and servomechanisms, where power supplies operate at 400 to 1000 cps, and where previous 60 cps instrumentation

(Continued on page 300)



Prolong machinery life and save money—

with FALK Steelflex Couplings

Ever since the first Falk Steelflex Coupling was designed and built, we have firmly held to these beliefs:

1. A coupling, to give fullest value, must do more than merely *connect* driving and driven machinery—it must *protect* the machinery and prolong its life.

2. A coupling, to be truly flexible, must overcome the effects of shock and vibration, as well as shaft misalignment.

Proof of the soundness of those beliefs is furnished by the record. More than one million Falk Steelflex Couplings have been used on every conceivable type of industrial application . . . giving trouble-free service, providing maximum protection to connected machinery.

* A single basic type—the famous Type F—fills 90% of all industrial application needs. It is versatile, efficient and economical. And—it is always available from factory, field or distributor stocks, in a wide range of sizes.

Write to Department 247 for engineering bulletin, including selection and dimension tables.

THE FALK CORPORATION, MILWAUKEE, WISCONSIN

MANUFACTURERS OF:

- Motoreducers
- Speed Reducers
- Flexible Couplings
- Shaft Mounted Drives
- High Speed Drives
- Special Gear Drives
- Single Helical Gears
- Herringbone Gears
- Marine Drives
- Steel Castings
- Weldments
- Contract Machining

FALK

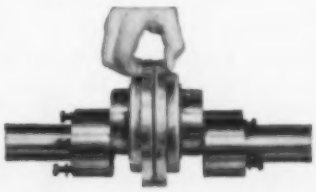
...a good name in industry

The New Type F Spacer Coupling

Here is a Steelflex coupling specially designed to permit fast, easy installation and removal in horizontal and vertical applications where it is impracticable to move the connected units—or where a space-gap (up to 12 in.) is necessary.

Like all Steelflex couplings, the Type F Spacer gives long, trouble-free service and maximum 3-way protection for connected machinery: it provides torsional resilience to reduce shock and vibration; it accommodates parallel or angular shaft misalignment; it allows free (or limited) end float.

An outstanding feature of the Steelflex Spacer is that it can be installed or removed in one piece (see photo below); no dismantling or servicing of the coupling is required. Pump assemblies can be disconnected and removed without disassembling the coupling, without exposing working parts.

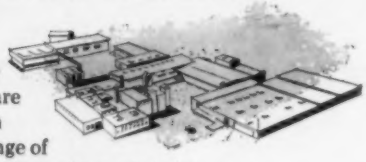


The Steelflex Spacer coupling is prelubricated at the Factory and can be installed, or removed and reinstalled, without disturbing the lubricant—a highly desirable feature.

COMPLETE DESIGN SERVICE!

Nobody could expect a busy design engineer to keep up with all properties of all thermoplastics. That's Gering's job—and we offer highly practical advice on thermoplastics for your specific application. Also ideas on possible design modifications to cut cost or simplify assembly. This is only *part* of Gering's complete engineering and design service—all under one roof...all under one responsibility backed by Gering's knowledge resulting from over thirty years experience of producing high quality plastics.

COMPLETE PRODUCTION FACILITIES!

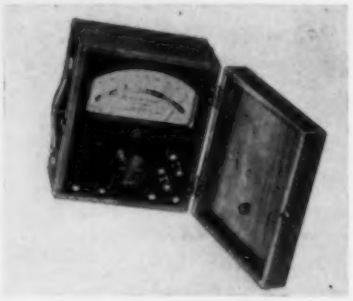


For fast service—backed by rigid quality control...come to Gering for all your thermoplastic extrusions. At your service are hundreds of dies...complete custom die-making...and a wide range of modern extruders. Why not send us your blueprint—let us bid on your next job. Find out for yourself that Gering means top quality plus dependable delivery...made possible only by one of the most complete and efficient extrusion plants in the world!

Gering Extrudes

Polyethylene, Acetate, Acrylic, Vinyl, Polystyrene, Butyrate; (Tenite II), Ethyl Cellulose, Copolymers

GERING
PRODUCTS, INC.
Monroe Street, Kenilworth, N. J.



is inadequate. They are electro-dynamometer type instruments with an entirely new coil system which results in an outstanding high-frequency response—a typical voltmeter having practically flat response to at least 1000 cps. Rawson Electrical Instrument Co., 110 Potter St., Cambridge 42, Mass.

For more information—
Circle 97, inside back cover

Recording Oscillograph

These oscillographs will operate under conditions such as: acceleration, 15 G along any major axis; temperature, −65 F to 160 F; humidity, up to 100 per cent; altitude, up to 100,000 ft above sea level. The 590 has a 36 trace capacity with 7 in. wide records; the 591 records a maximum of 50 traces on 12 in. records. Such components as power supply units, timing units, record identification units and transmissions are completely interchangeable.

The units have five basic recording speeds, and magnetic clutches in the transmission will multiply these by factors of 1, 4, 16, or 64 producing a total of 20 separate recording speeds. Midwestern Instruments, 41 and Sheridan Road, Tulsa, Okla.

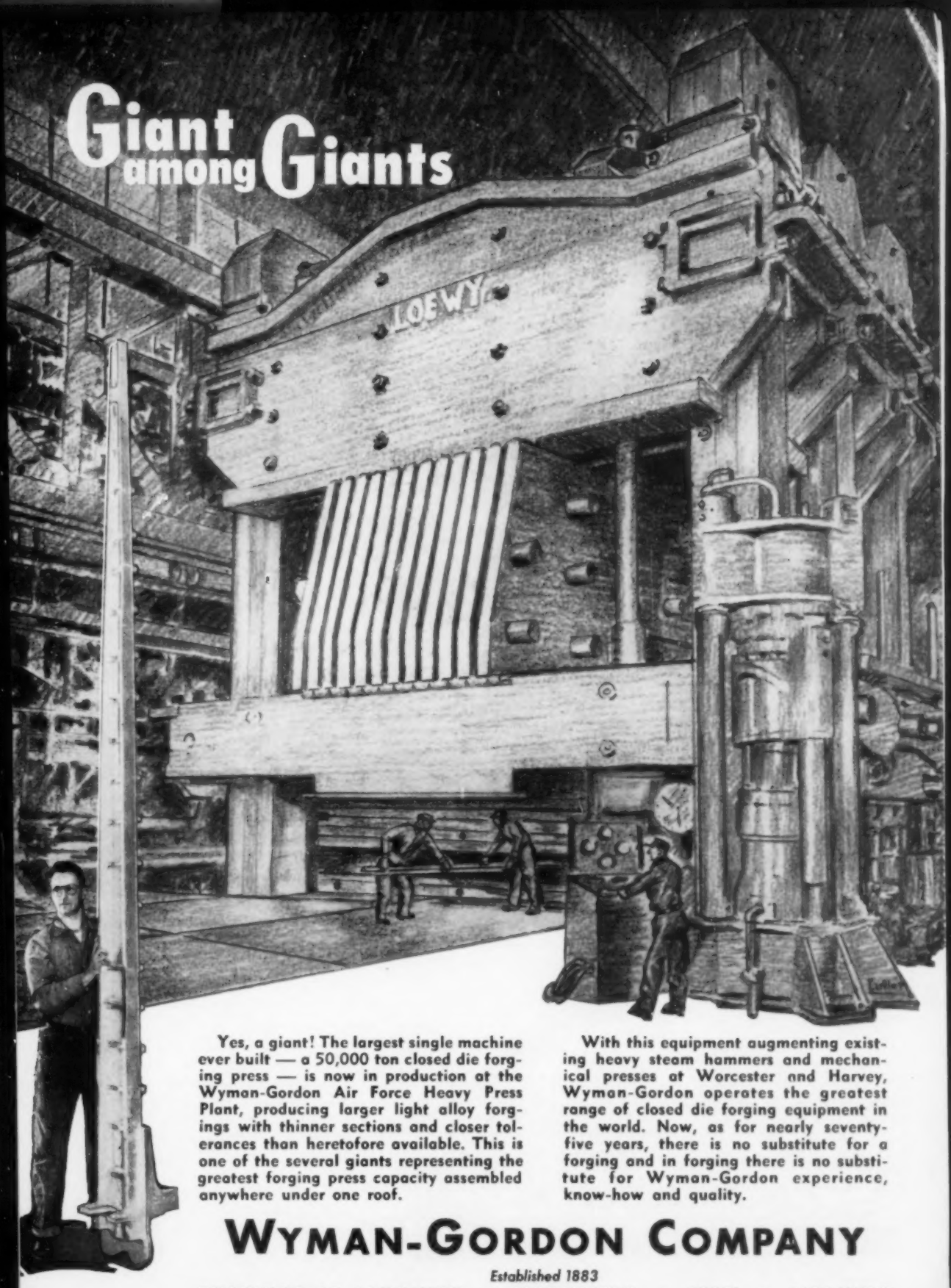
For more information—
Circle 98, inside back cover

Cathode Ray Tube Retains Traces

A direct-display storage tube is available for industrial and laboratory use which can capture and retain visual displays of transients without resorting to photography. Employing a special storage target just behind the viewing screen, this 5 in. tube retains single tracings or successive writings at high

(Continued on page 303)

Giant among Giants



Yes, a giant! The largest single machine ever built — a 50,000 ton closed die forging press — is now in production at the Wyman-Gordon Air Force Heavy Press Plant, producing larger light alloy forgings with thinner sections and closer tolerances than heretofore available. This is one of the several giants representing the greatest forging press capacity assembled anywhere under one roof.

With this equipment augmenting existing heavy steam hammers and mechanical presses at Worcester and Harvey, Wyman-Gordon operates the greatest range of closed die forging equipment in the world. Now, as for nearly seventy-five years, there is no substitute for a forging and in forging there is no substitute for Wyman-Gordon experience, know-how and quality.

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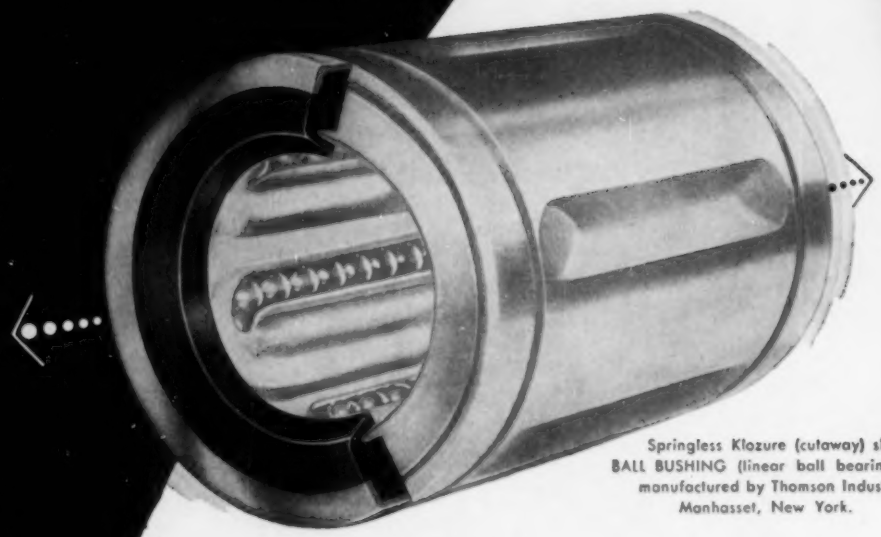

Springless Klozure (cutaway) shown on a BALL BUSHING (linear ball bearing) manufactured by Thomson Industries, Inc., Manhasset, New York.

First Choice

FOR LINEAR MOTION, TOO!

Klozure* Oil Seals Protecting bearings from dust and other contamination is as important in linear applications as it is in rotary bearing applications. That's why Thomson Industries, selected Garlock Klozure Oil Seals Model 71-A for their linear ball bearing. Thomson found that the unique design of the 71-A and its synthetic rubber sealing element made it ideal for their limited space, low pressure, grease retaining application.

Let us show you how one of "the Garlock 2,000" can help you . . . you can choose from two thousand different styles of packings, gaskets, and seals to meet all your needs. It's the only *complete* line . . . it's one reason you get *unbiased* recommendations from your Garlock representative. Call him today or write for Klozure Catalog 10.

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THE GARLOCK PACKING COMPANY, Palmyra, New York

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Packings, Gaskets, Oil Seals, Mechanical Seals, Rubber Expansion Joints

brightness, until they are intentionally erased. Photography need be used only when permanent records of selected traces are required for files.

According to the manufacturer, some general specifications of the tube are as follows: resolution, 60 written lines per inch; brightness, 50 foot-lamberts; usable screen diameter, 4 in., min. Hughes Products, Los Angeles 45, Calif.

For more information—
Circle 99, inside back cover

Table-Top Reproduction Machine

This machine has a 30 in. printing width, top mechanical speed of 8 ft 10 in. per minute, variable speed drive with selenium rectifiers, 1200 w quartz lamp with 34 in. active length, and a 12 x 30 in. rear delivery tray. The device operates on a 115-v, 60 cps, 17.2 amp, ac.

The machine does not require any vents, darkroom facilities or auxiliary equipment. Exposure and development are automatically synchronized; a single control knob turns the machine on or off and regulates its speed. The unit is 15 x 45¾ x 31 in. deep. Charles Bruning Co., Inc., 4700 Montrose Ave., Chicago 41, Ill.

For more information—
Circle 100, inside back cover

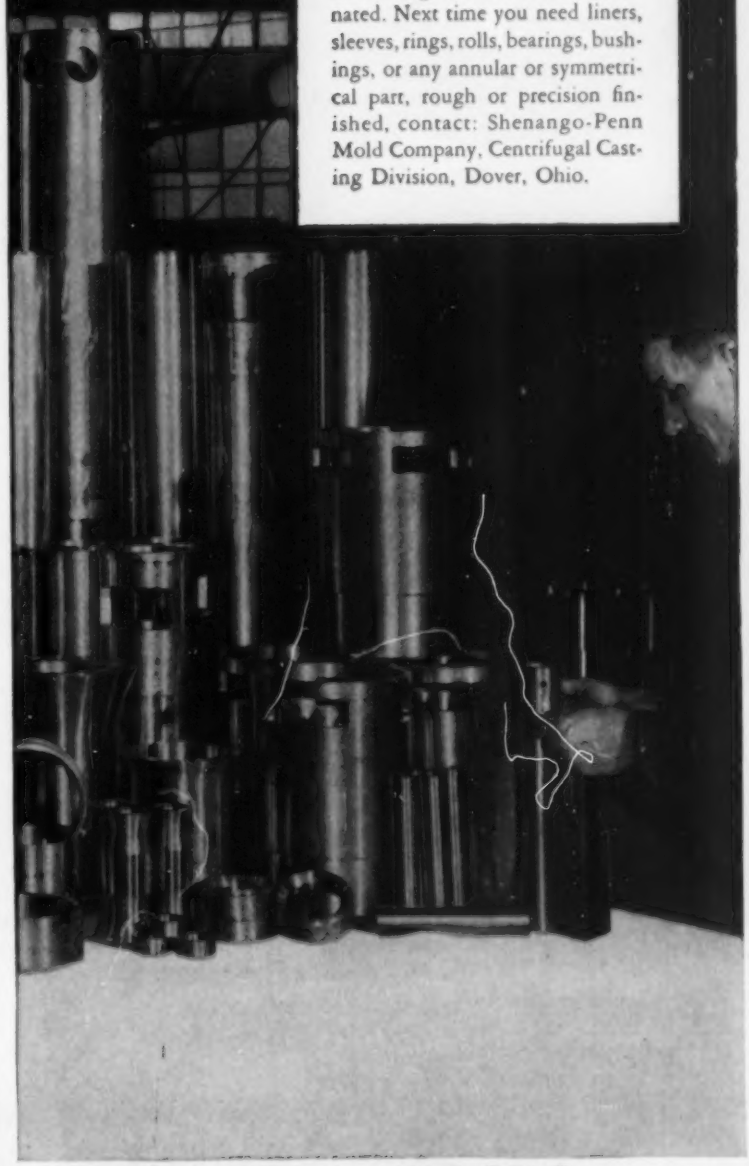
Ball Point Printed Circuit Dispenser

Liquid resist for printed circuits contained in ball point dispensing tubes will withstand nitric acid in etching the finished layout of a printed circuit. The resist comes in several colors, making it possible when laying out the circuit to color code the wiring for checking out the prototype unit. The resist is also electrically an insulator, and can be left on as a

(Continued on page 306)

How SHENANGO CENTRIFUGAL CASTINGS pay off!

NO ROOM FOR TROUBLE... because all these parts have been centrifugally cast by Shenango. Centrifugal action forces all gas and impurities from the molten metal. Defects that ordinarily show up in machining or service are eliminated. Next time you need liners, sleeves, rings, rolls, bearings, bushings, or any annular or symmetrical part, rough or precision finished, contact: Shenango-Penn Mold Company, Centrifugal Casting Division, Dover, Ohio.



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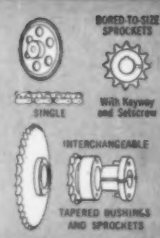
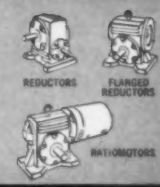


SPEED REDUCERS



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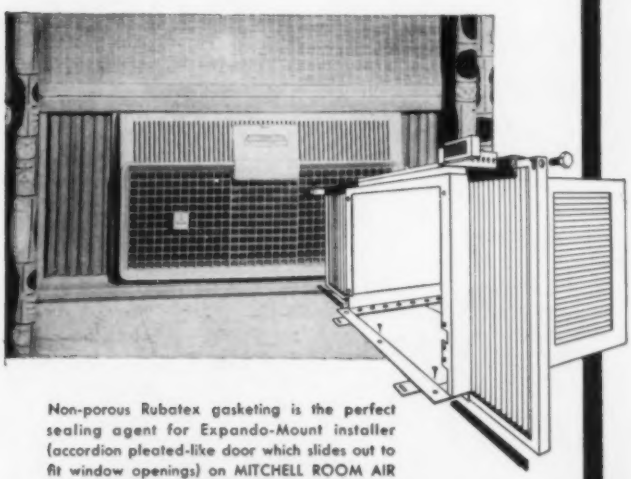
Layers of Rubatex assure tight effective seal between metal pylon and metal wing surface of CHANCE VOUGHT'S F7U-3 CUTLASS. Also valuable for streamlining purposes and cushions the two metals when pylon is attached to wing of jet fighter.

Rubatex gives air, dust and moisture a technical shut out as an effective non-corrosive seal around door and glass of new U. S. GAUGE PRESSURE PILOT. Dribak adhesive on smooth surface of Rubatex makes application easy and sure.



Non-porous Rubatex gasketing is the perfect sealing agent for Expando-Mount installer (accordion pleated-like door which slides out to fit window openings) on MITCHELL ROOM AIR CONDITIONERS. Insures complete, durable, air-tight, water-tight, dust-tight installation for life of air conditioner.

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Stainless steel hinge for military ordnance component was formerly composed of a stamped bracket and machined hinge, welded together and assembled to a complicated anti-rotation device. Entire unit is now cast in one piece and is lighter and stronger. Hole-reaming is only machining required.

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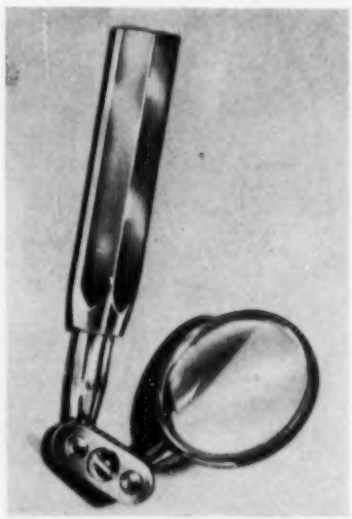
permanent protective coating to the copper circuit against corrosion and dirt. Each tube will deposit circuitry ☆ in. wide. Techniques, 178-84 Central Ave., Hackensack, N. J.

For more information—
Circle 101, inside back cover

Power Supply Rated At 15 Kva

The 15 kva unit provides a precisely regulated 401.08-cps, three-phase output, with frequency regulation held constant within 0.01 per cent, no-load to full load, 80 to 100 per cent power factor. The motor-generator set operates from a standard 220/440-v, three-phase, 60-cps supply. Drive motor, magnetic clutch, generator, and exciter are in-line mounted on a common base. A remote console houses the starting and output controls, meters for monitoring voltage and current, and the regulator components. Electric Specialty Co., 211 S. St., Stamford, Conn.

For more information—
Circle 102, inside back cover

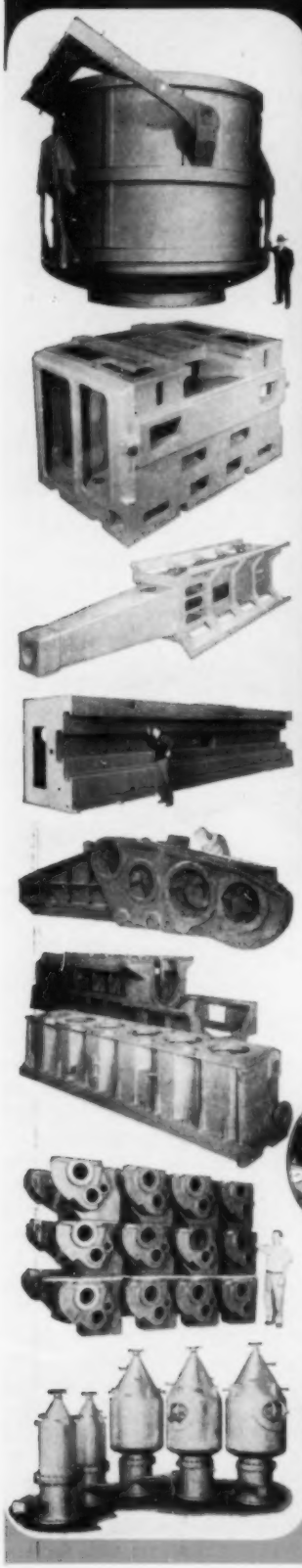


Mirror-Magnet Assembly

This device was designed to simplify examination of the bore of all firearms for proper cleaning and maintenance. It can similarly be used to inspect the interior surface of any hollow, lengthy part.

The unit consists of a powerful Alnico V magnet in a heavy brass

(Continued on page 308)



Use WELDED STEEL for Greater Strength with Less Weight!

The 50-ton weldment above is one of fifty-five identical Press Beds produced for one manufacturer of heavy presses. This piece, and the parts and assemblies illustrated at the left, are typical of thousands of Steel-Weld Fabricated units produced and machined by Mahon for manufacturers of processing machinery, machine tools, and other types of heavy mechanical equipment. Are you taking full advantage of the possibilities offered by welded steel components in your products? In the design of almost any type of heavy machinery there are pieces and sub-assemblies that can be produced more satisfactorily and more economically in welded steel —and with the additional advantages of less weight, greater rigidity and predictability. When you consider weldments, think of Mahon . . . because, you will find the Mahon organization a unique source for welded steel in any form . . . a source with complete facilities for design engineering, fabricating, machining and assembling . . . a source where design skill and advanced fabricating techniques are supplemented by craftsmanship which assures you a finer appearing product embodying every advantage of Steel-Weld Fabrication. See Sweet's Product Design File for information, or, better still, have a Mahon sales engineer call at your convenience.

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Whitney Roller, Silent and Conveyor Chain is available in all A.S.A. sizes. Attachments for Roller and Conveyor Chain increase adaptability and design possibilities. Whitney Sprockets are furnished in all standard types . . . from stock or made to order. Whitney Flexible Couplings are designed for wide adaptability, easy assembly, positive operation and long life.

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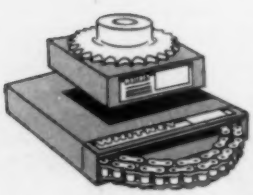

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core, chromium finished, with a swivel-mounted mirror. The handle is 2¼ in. long, the mirror itself less than 1 in. dia. Ullman Products Corp., 15 River St., Norwalk, Conn.

For more information—
Circle 103, inside back cover

Rack for Drafting Board

Clamped to the back corners of the drawing board, this device permits practically any size of reference material to be hung in a position where it is easily referred to. The rack consists of two telescoping tubes that can be placed as much as 36 in. apart. The reference material is hung with clips on a cord stretched between the grooved tips. Draftray Co., 1316 E. 24 St., Minneapolis 4, Minn.

For more information—
Circle 104, inside back cover

Digital Computer

This frequency counter computer is small (14½ x 7 x 19 in. wide for standard relay rack amount). The Model 309 indicates pressure, temperature and flow directly in numbers from the frequency signals of the sensing gages. This new PTF computer gives a visual read-out from 000 to 999 in steps of 1, thus providing a percentage type indication for maximum utilization of digits. Performance is read instantly without translation.

The computer may be used in conjunction with a printer or electric typewriter to produce permanent digital recording of the processed data. Digital output signals from the computer can be made available in either binary or decimal form. Byron Jackson Div., Borg-Warner Corp., P. O. Box 2017A, Terminal Annex, Los Angeles 54, Calif.

For more information—
Circle 105, inside back cover

New "Personal" portable TV by RCA Victor occupies less space than many table model radios. Coating based on BAKELITE Vinyl Resins formulated by **John L. Armitage & Company,** Newark, New Jersey.

Tough textured coating

for TV that travels

"In designing the 'Personal' TV, it was apparent that by its very nature this versatile set would be used in a variety of locations—patios, recreation rooms and kitchens. An attractive, durable, scuff-resistant finish was needed. RCA Victor selected a coating based on BAKELITE Brand Vinyl Resins. Colored, textured and tough, this finish withstands the demanding wear of portable usage."—*A report from RCA Victor.*

Have a new product problem in coatings? A wide selection of coatings based on BAKELITE Brand Vinyl Resins may provide the answers. These finishes give long-lasting protection against corrosives, temperature extremes, abrasion and destructive atmospheres.

If you would like a list of suppliers of coatings based on BAKELITE Resins and a free copy of our booklet, "Coatings for General Industry," write Dept. RZ-145.

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Scientifically planned to aid YOU in your work . . . designed to support you comfortably whether you're chewing your pencil or bent over hard at work . . . engineered from the quality materials YOU would recommend, with independently adjustable seat, back and footring to conform to your physique . . . and with removable, replaceable covers in a wide range of fabrics and colors to match YOUR decorating plan.

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CATALOGS and BULLETINS

To obtain copies of literature described below, circle corresponding number on postcard inside back cover. For those catalogs and bulletins available only when requested on company letterhead, see page 329.

Switches–Catalog C, 12 pp, describes appliance, aircraft, automotive, electronic, marine, motor control and special application switches. Included are illustrations, ratings, dimensions and specifications. Carling Electric, Inc., 505 New Park Ave., W. Hartford 10, Conn.

Circle 106, inside back cover

Fastenings–Booklet G20, 12 pp, covers plating and surface treatment of hex socket screws and other products. Allen Mfg. Co., 133 Sheldon St., Hartford 2, Conn.

Circle 107, inside back cover

Bronze Bearings, Bushings–Catalog 56, 109 pp, covers line of industrial bearings, bushings and bars. Johnson Bronze Co., New Castle, Pa.

Circle 108, inside back cover

V-Belts–Bulletin V-1400-B20-P, 8 pp, describes V-Belts available for drives employed in heavy industrial applications and miscellaneous light machinery. Contains a complete listing of multiple V-Belt sizes available. Worthington Corp., Oil City, Pa.

Circle 109, inside back cover

Plastics–Catalog, 100 pp, has data on all types of plastics, definitions and detailed information on buying and working plastics. Includes such materials as acetate, lucite, plexiglas, vinyls, saran, nylon, polyethylene, phenolics, polystyrene, polyesters, reinforced plastics, coatings. Fry Plastics Co., 7826 S. Vermont Ave., Los Angeles 44, Calif.

Circle 110, inside back cover

Hydraulic Pumps, Valves–Booklet, 24 pp, contains descriptive folder, engineering drawings, price list. Simplex Engineering Co., Zanesville, Ohio.

Circle 111, inside back cover

Right-Angle Gearmotor – Booklet B-6579, 4 pp, describes gearmotor for applications requiring 1 to 30 hp. Westinghouse Electric Corp., P. O. Box 2099, Pittsburgh 30, Pa.

Circle 112, inside back cover

Vinyl-Metal Laminates–Booklet 12 pp, has samples and physical properties of a semi-sized vinyl sheeting bonded to metal, with suggestions for use. Columbus Coated Fabrics Corp., Columbus 16, Ohio.

Circle 113, inside back cover

V-Belts and Sheaves–Booklet 20P50, 44 pp. In addition to providing selection tables for A, B, C and D section variable speed drives, the booklet includes information on design features, drive principles, horsepower rating tables for section belts, a speed range table showing the variation in rpm when using two sheaves in combination, and accessory equipment. Allis-Chalmers Mfg. Co., 1002 S. 70 St., Milwaukee, Wis.

Circle 114, inside back cover

Compressors–Booklet, 12 pp, with flow charts in colors describes a means whereby compressors can be staged in conjunction with the use of a wide range coil. The horsepower required for the first stages is reduced compared with ordinary air conditioning methods. A. I. McFarlan Co., 90 West St., New York 6, N. Y.

Circle 115, inside back cover

Canned Motor Pumps–Bulletin 1050, 4 pp, has performance curves, dimensions, principles of construction and operation, cut-away views, materials available, power requirements. Chempump Corp., Station M, 1300 E. Mermaid Lane, Philadelphia 18, Pa.

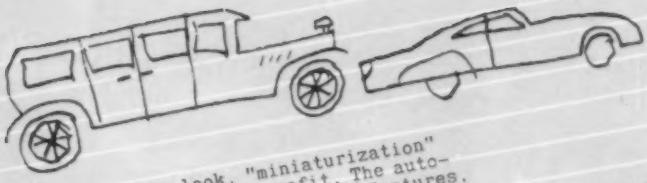
Circle 116, inside back cover

Rotary Gear Pump–Booklet, 14 pp, gives dimensions, ratings, other data on steel block pumps. Northern Ordnance Inc., subsidiary Northern Pump Co., Columbia Heights, P.O., Minneapolis, Minn.

Circle 117, inside back cover

Investment Castings–Booklet, 40 pp, contains physical, mechanical and chemical properties of 26 investment-casting alloys. Haynes Stellite Co.,

(Continued on page 313)



Everywhere you look, "miniaturization" has meant progress and profit. The automobile is packed with many more features, much more power, all in the same space through miniaturization.

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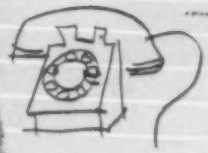
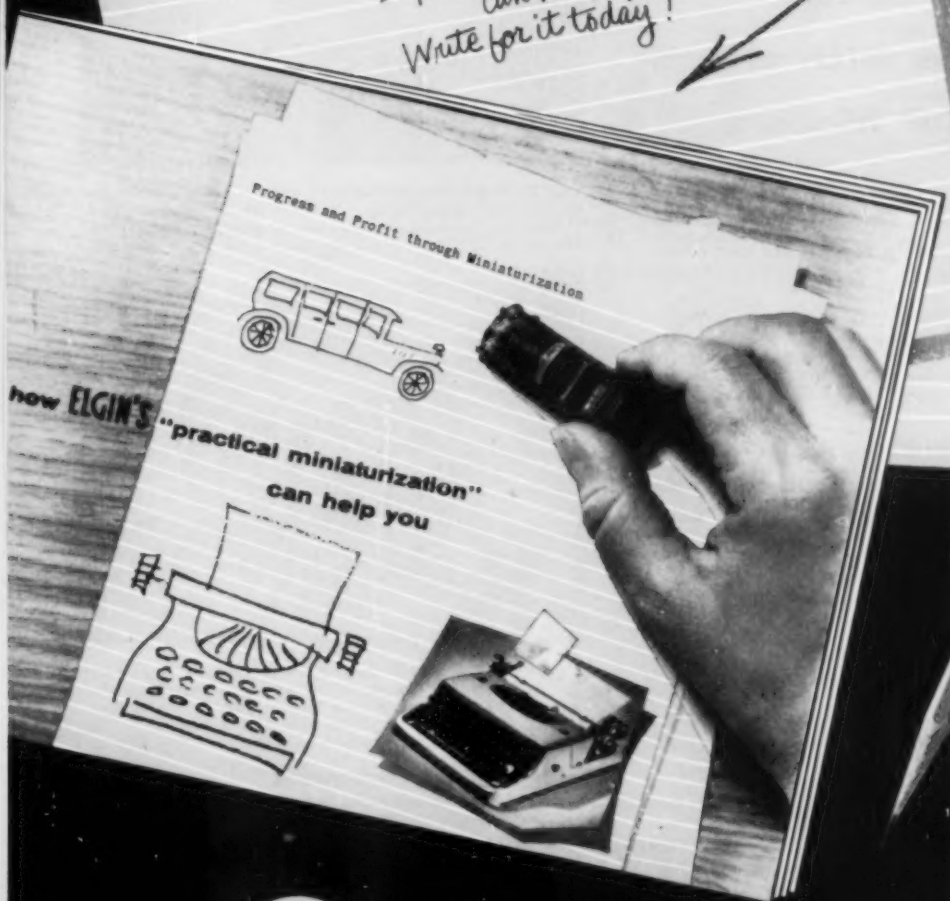
This book tells how Elgin's "Practical Miniaturization" can help you! Write for it today!



Today's telephone depends on more dependable, "miniaturized" assemblies. Better performance, reduced costs—these are the keynotes of "Practical Miniaturization".



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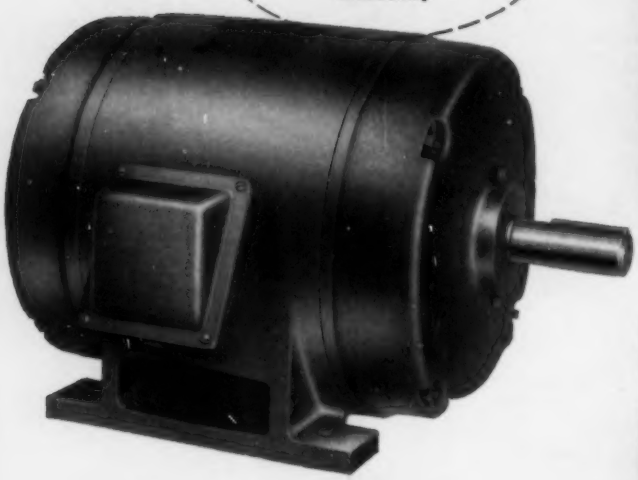
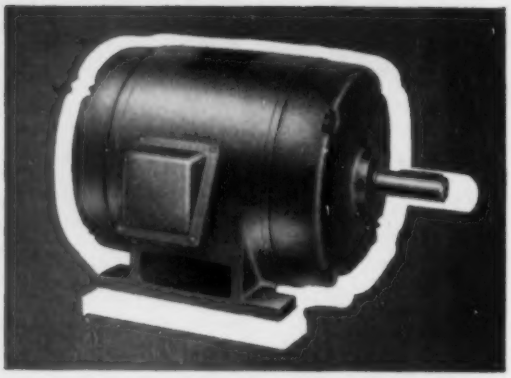


You get better performance with these Wagner DP Motors

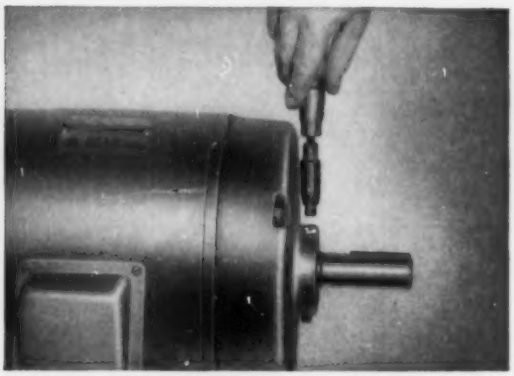
Wagner DP motors are *doubly protected* by (1) rugged, corrosion-resistant cast iron frames, smoothly rounded so that no moisture can collect on them. Motor feet are cast as an integral part of the frame for maximum strength and rigidity. (2) Enclosures on the DP motor are completely drip-proof—virtually splashproof. Air intakes are located at the bottom of the endplates and air outlets are located at the base of the frame—one on each side.

Although engineered to meet the re-rated NEMA specifications which call for more power in smaller frames, the same high quality and long life performance that have made Wagner Motors "the choice of leaders in industry" for many years has of course been retained.

Full information and principal dimensions are given in Bulletin MU-202. Write for your copy today.



MORE POWER IN SMALLER FRAMES The Wagner DP Motor packs more power in a smaller frame and this smaller size means ease of handling and stocking . . . less space required for installation.



CAN BE RE-GREASED FOR LONGER LIFE This motor will operate for years without regreasing . . . bearings are completely enclosed . . . however, provisions have been made for adding lubricant and for the removal of old grease in cases where re-greasing is necessary.

COOL RUNNING Specially designed baffles direct cooling air from the blowers through the motor and provide protection for the stator windings. Blowers are an integral part of rotor . . . and move large volumes of air without noise or vibration.

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ELECTRIC MOTORS • TRANSFORMERS • INDUSTRIAL BRAKES • AUTOMOTIVE BRAKE SYSTEMS-AIR AND HYDRAULIC

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Circle 118, inside back cover

Plastic-Impregnated Moldings–Catalog C-56, 14 pp, gives information and various specification tables. Continental-Diamond Fibre Div., Budd Co., Inc., Newark, Del.

Circle 119, inside back cover

Miniature Connector–Bulletin, 4 pp. provides specifications and applications for seven connector series. Gorn Electric Co., Inc., Electronics Div., Stamford, Conn.

Circle 120, inside back cover

Steel Castings–Bulletin 556-C (chart), identifies ACI and Empire designations with corresponding AISI type number, ASTM designation and other designations and trade names of similar alloys. Empire Steel Castings, Inc., Reading, Pa.

Circle 121, inside back cover

Stroke and Revolution Counters–Catalog M200, 7 pp, shows special counter assemblies for built-in application as well as individual number wheels, reset gears, shafts. Production Instrument Co., 702-10 W. Jackson Blvd., Chicago 6, Ill.

Circle 122, inside back cover

Aluminum Impact Extrusions–Manual, 32 pp, describes recently developed techniques, industrial and commercial applications. Aluminum Co. of America, Alcoa Bldg., Pittsburgh 19, Pa.

Circle 123, inside back cover

Stainless Steels–Technical Study 3, 10 pp, discusses chromium-nickel-manganese steels, and provides detailed charts, graphs and information on cold rolled mechanical properties, elevated temperature properties, physical properties and corrosion resistance. Allegheny Ludlum Steel Corp., 2020 Oliver Bldg., Pittsburgh 22, Pa.

Circle 124, inside back cover

Solenoids–Bulletin 200, 6 pp, describes a-c and d-c solid frame, and a-c laminated solenoids. Comar Electric Co., 3349 Addison St., Chicago 18, Ill.

Circle 125, inside back cover

Electric Motors–Technical data sheet, 1 pp, has dimensions and reference drawings for motors in the new NEMA

(Continued on page 314)

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actual size

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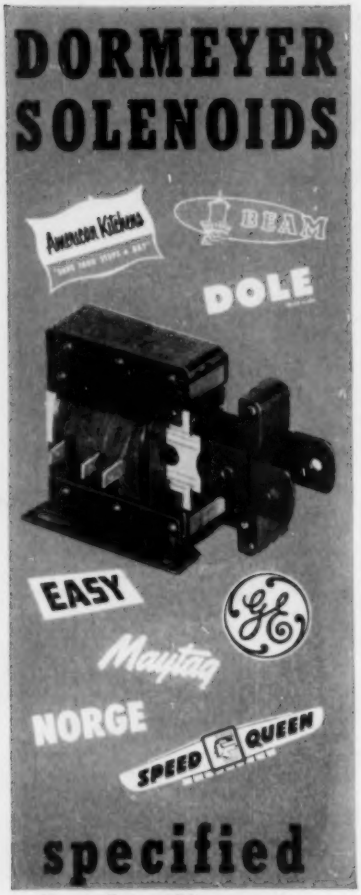

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Catalogs and Bulletins . . . . . continued

standard sizes. Acec Electric Corp., 40 E. 49th St., New York 17, N. Y.
Circle 126, inside back cover

Speed Reducers—Bulletin 600-C, 8pp, describes double-enveloping worm gear reducers and gives specifications and horsepower ratings. Cone-Drive Gears, Div. Michigan Tool Co., 7171 E. McNichols Road, Detroit 12, Mich.
Circle 127, inside back cover

Miniature Relay—Bulletin, 2 pp, has complete description, technical data, and illustrations on mercury plunger relay. Ebert Electronics Corp., 212-329 Jamaica Ave., Queens Village 28, N. Y.
Circle 128, inside back cover

Mechanical Seals—Bulletin S-205-2, 8 pp, provides construction, service and application information. Crane Packing Co., Dept. PEN, 6400 Oakton St., Morton Grove, Ill.
Circle 129, inside back cover

Digital Instruments—Catalog 356, 28 pp, contains illustrations, charts and characteristics of automatic digital ohmmeters, readouts, data reduction systems, peak reader systems, recording systems, a-c d-c converters and binary decimal converters. Non-Linear Systems, Inc. Del Mar Airport, Del Mar, Calif.
Circle 130, inside back cover

Sensing Devices—Catalog, 19pp, describes thermistors, varistors, and assemblies and contains technical data and illustrations. Victory Engineering Corp., Springfield Road, Union, N. J.
Circle 131, inside back cover

Solenoid Valves—Catalog 200, 22 pp, describes line of electrically operated two-way solenoid valves for air, gas, steam and liquid flow control. Lists available dimensions, specifications, pressures, applications and includes price list. Atkomatic Valve Co., Inc., 545 W. Abbott St., Indianapolis, Ind.
Circle 132, inside back cover

Titanium—Bulletin, 8pp, contains currently available data on corrosion resistance and suggests applications. Mallory-Sharon Titanium Corp., Niles, Ohio.
Circle 133, inside back cover

Ceramic Parts—Bulletin 563, 4 pp, supplies mechanical and electrical
(Continued on page 318)

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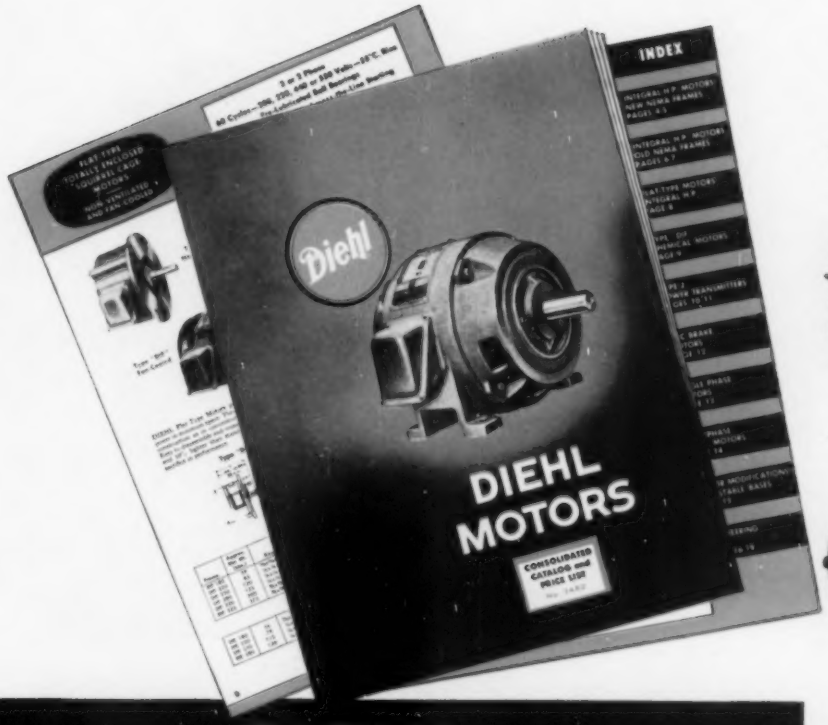

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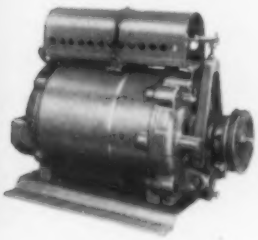

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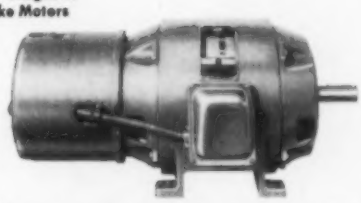

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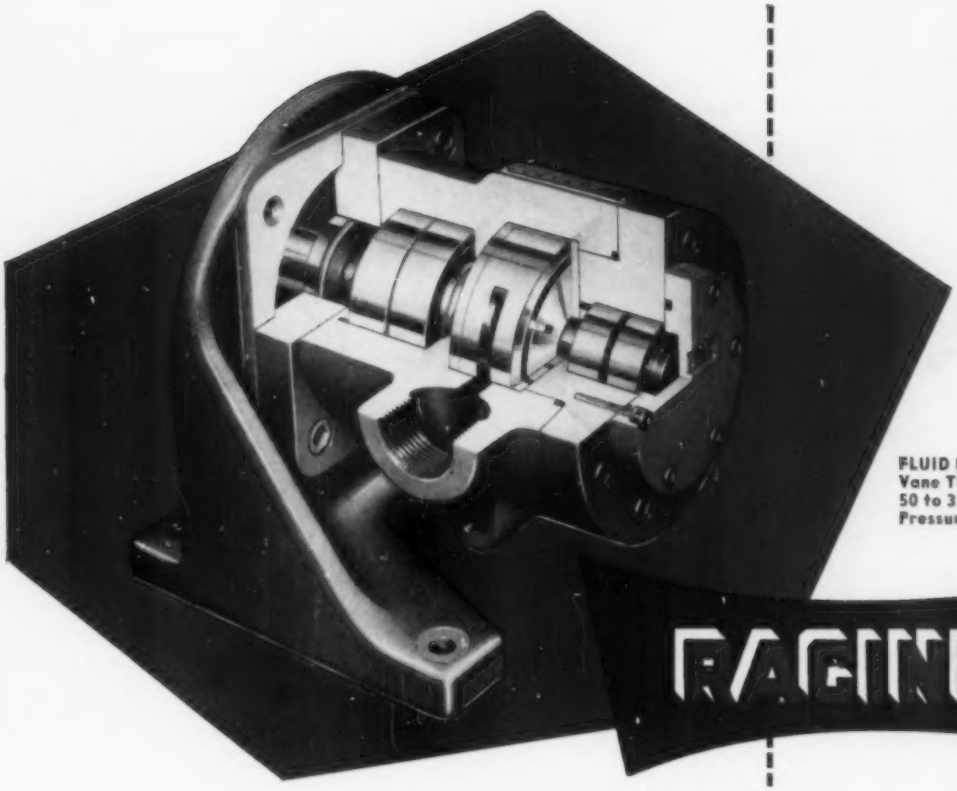

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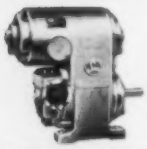

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Catalogs and Bulletins.....continued

properties of technical ceramics. American Lava Corp., Chattanooga 5, Tenn.
Circle 134, inside back cover

Industrial Wheels—Catalog HW-56, 4 pp, describes design and construction features of different wheel combinations. American Pulley Co., 4200, Wissahickon Ave., Philadelphia 29.
Circle 135, inside back cover

Resistors—Bulletin PH, 4 pp, has specifications and descriptions for more than 50 types of resistors. Hycor Div., International Resistance Co., 12970 Bradley Ave., Sylmar, Calif.
Circle 136, inside back cover

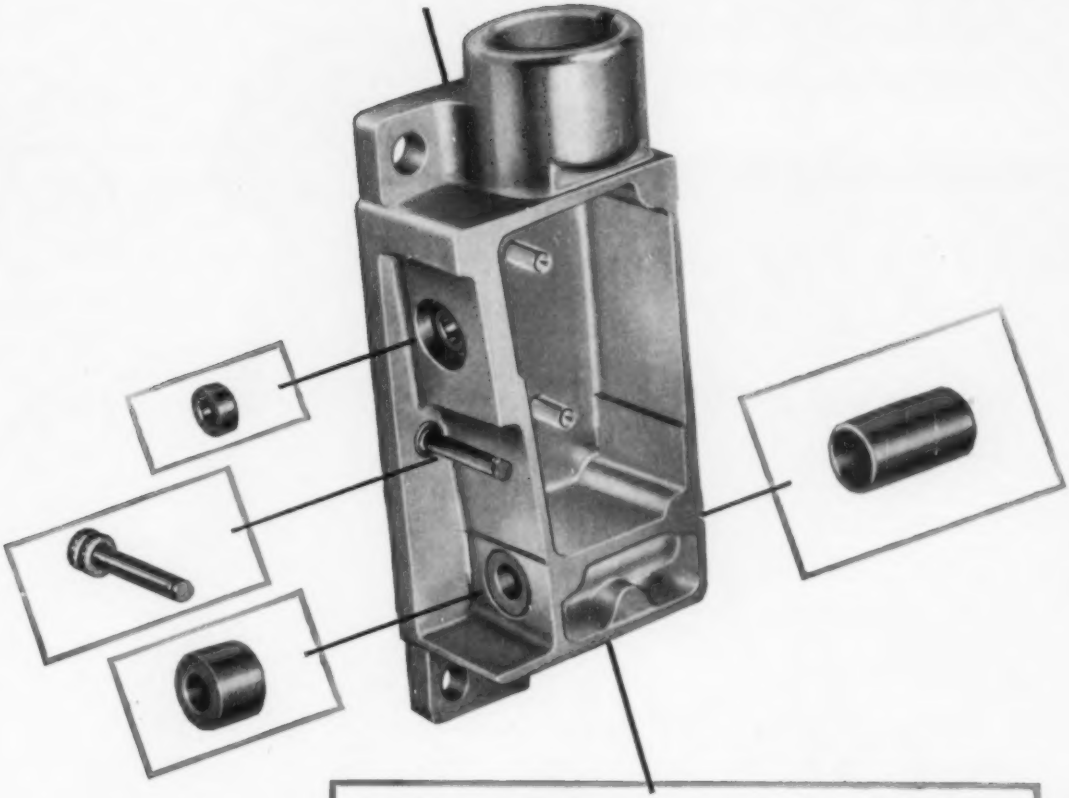
Precision Components—Bulletin G-3, 4 pp. contains specifications for encapsulated precision wire-wound reature magnetic clutches, precision wave filters, telemetering filter, precision ratio transformers, miniature toroid power transformers, magnetic amplifiers, decade inductor units, program equalizers, variable filters and variable attenuators. Hycor, 12970 Bradley Ave., Sylmar, Calif.
Circle 137, inside back cover

Plastics—Booklet, 48 pp, contains basic facts on sources and production of plastics, their growth and use in everyday living. The important qualities, familiar uses, origins and resins are given for phenolic, vinyls, polysterenes and polyethelenses in graphic and tabular form. Bakelite Co., Div. Union Carbide & Carbon Corp., 300 Madison Ave., New York 16, N. Y.
Circle 138, inside back cover

Panel Instruments—Bulletin GEC-368H, 12 pp, describes application, construction, dimensions and other data of 2½, 3½ and 4½ in. sizes. General Electric Co., Schenectdy 5, N.Y.
Circle 139, inside back cover

Polyester Laminates—Booklet, 12 pp, tells of dielectric and physical properties of inorganic mat-reinforced polyester sheet insulation. Insulation Manufacturers Corp., 565 W. Washington Blvd., Chicago 6, Ill.
Circle 140, inside back cover

Molding Compounds—Manual, 50 pp, covers descriptions of melamine molding compounds, characteristics, storage and handling, performing, preheating, molds, design of molded parts, molding procedures, molding variables,
(Continued on page 321)



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finishing and typical applications. American Cyanamid Co., 30 Rockefeller Plaze, New York 20, N. Y.

Circle 141, inside back cover

Sub-Fhp Motors and Blowers–Folder, 4 pp, contains ratings, torques, speeds, dimensions and weights. Fairchild Industries, 110 Main St., Burlington, Vt.

Circle 142, inside back cover

Tubing and Pipe–Booklet, 11 pp. describes copper and brass tubing and pipe, includes alloys, tempers, lengths, specifications, applications, properties. Lewin-Mathes Co., 1111 Chouteau Ave., St. Louis 2, Mo.

Circle 143, inside back cover

Sprockets and Gears–Folder, 4 pp, gives types available, dimensions, materials. E. B. Sewall Mfg. Co., 705 Raymond Ave., St. Paul 14, Minn.

Circle 144, inside back cover

Ohm's Law Calculator–Permits determinations of ohms when watts, volts, other factors are known, when ohms are not known. Also has parallel resistance calculator and standard slide rule. Ohmite Mfg. Co., 4835 W. Fluornoy St., Chicago 44, Ill.

Circle 145, inside back cover

Automatic Lubrication – Bulletin 806-R, 8pp, describes centralized systems, equipment, accessories, designs. Lincoln Engineering Co., St. Louis 20, Mo.

Circle 146, inside back cover

Fhp Permanent Magnet Motors–Catalog F4344-3, 4pp, describes motors, gearheads, centrifugal blowers, and tachometer generators. Barber-Colman Co., 1400 Rock St., Rockford, Ill.

Circle 147, inside back cover

Shaft Couplings–Catalog V-169-E, 8pp, gives specifications, list prices, ratings, dimensions of fixed bore, chain, flexible and rigid types. Browning Mfg. Co., Maysville, Ky.

Circle 148, inside back cover

Grooved Fasteners–Catalog, 24pp, illustrates and describes lock pins, studs and dowels. Tables and reference material are included. Driv-Lok Pin Co., Sycamore, Ill.

Circle 149, inside back cover

Stainless Pipe–Bulletin TB-410, 8pp, deals with seamless and welded stain-

(Continued on page 322)

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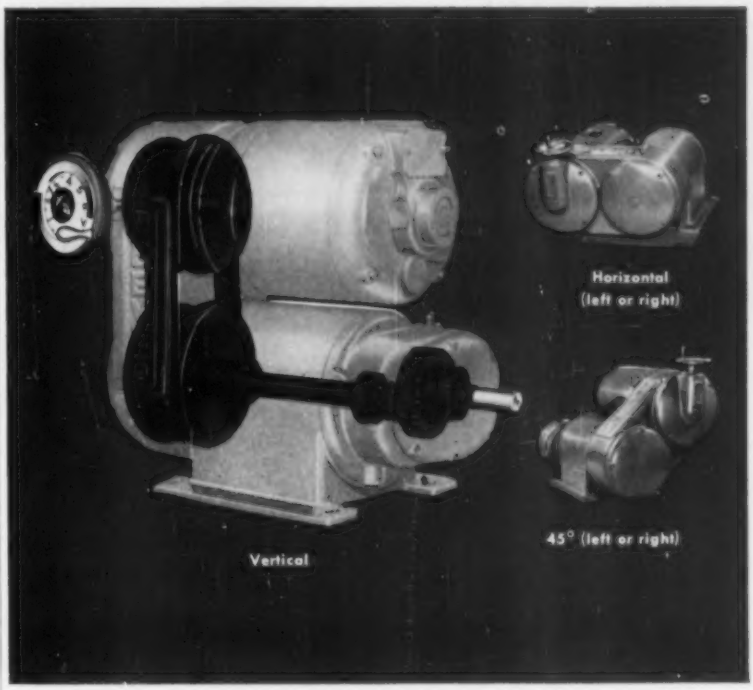

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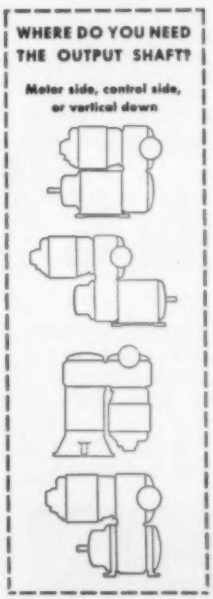

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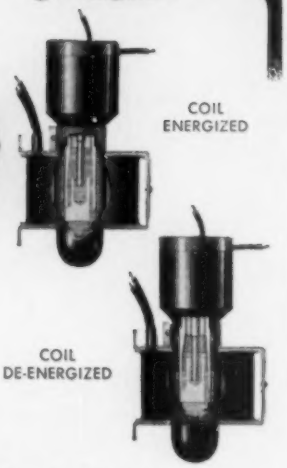

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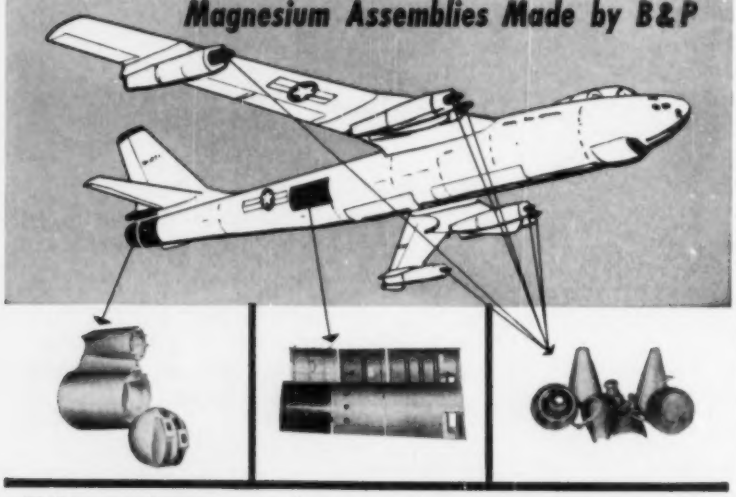

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less steel pipe and welding fittings where corrosion and/or elevated temperatures are determining factors. Babcock & Wilcox Co., Beaver Falls, Pa.
Circle 150, inside back cover

Machine Tool Electrical Standards—1956 edition, 38pp, discusses such subjects as motor and circuit protection, control circuits and circuit enclosures, and specifications for conductors. A section devoted to raceways and junction boxes represents considerable new material. A 3pp index and a glossary of electrical terms is given. National Machine Tool Builders' Assn., 2071 E. 102 St., Cleveland 6, Ohio.
Circle 151, inside back cover

Torque Tools—Manual, 27pp, is expanded second edition. Now includes additional torque application formulas. There are more suggested application illustrations. Tables show screw torque data including minimum torsional strength tabulations, torque and tension relationship charts for high tensile and mild steel screws and torque conversion tables. P. A. Sturtevant Co., Addison, Ill.
Circle 152, inside back cover

Bronze Bearings—Stock List-S-56, 21 pp, gives dimensions of bearings ranging in size from ⅛ to 4 in. ID. Amplex Div., Chrysler Corp., Detroit 31, Mich.
Circle 153, inside back cover

Instrument Tubing—Bulletin 456, 4pp, gives information on advantages, limitations, installation and available stock sizes and colors for each product. Dekoron Products Div., Samuel Moore & Co., Mantua, Ohio.
Circle 154, inside back cover

Synthetic Rubber—Booklet, 8pp, describes chemistry, properties. E. I. DuPont de Nemours & Co., Inc., Wilmington 98, Del.
Circle 155, inside back cover

Electric Brakes and Clutches—Bulletin WEB6212, 8pp. has complete specifications for primary electric brakes, clutches, clutch-brakes, clutch-couplings. Warner Electric Brake & Clutch Co., Beloit, Wis.
Circle 156, inside back cover

Powder Metallurgy — Bibliography, 12pp, refers to nearly 250 articles and papers printed in more than 50 US,
(Continued on page 325)

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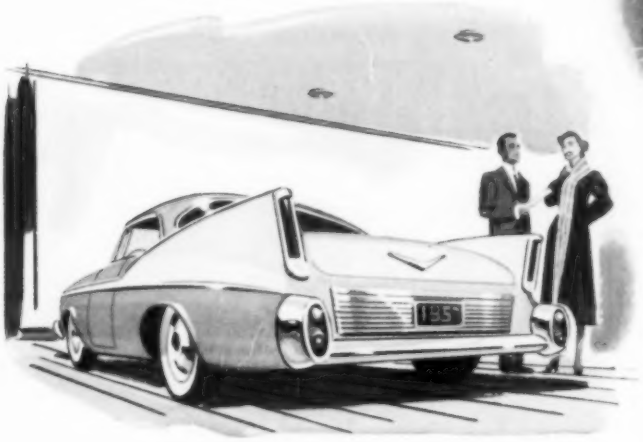

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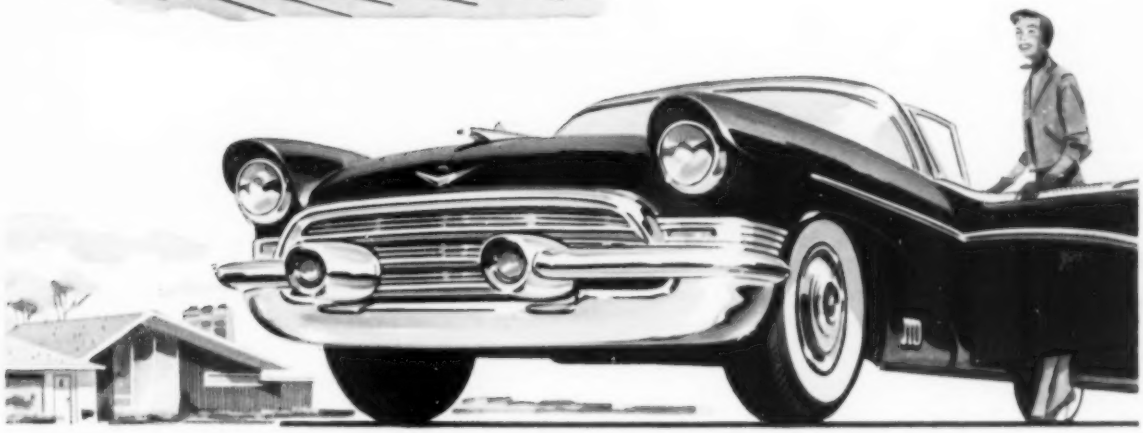

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For every industrial, agricultural or automotive application where braking is required!

TDA Plants at: Detroit, Michigan • Oshkosh, Wisconsin • Utica, New York
Ashtabula, Kenton and Newark, Ohio • New Castle, Pennsylvania

English and Canadian technical journals, trade magazines, and business papers during 1954 and 1955, with a few selected earlier references. In addition, 11 general powder metallurgy references and currently used textbooks are included. Harper Electric Corp., 39 River St., Buffalo, N. Y.

Circle 157, inside back cover

Wire Cloth—House organ, first issue discusses alloy selection, applications. Cambridge Wire Cloth Co., Cambridge, Md.

Circle 158, inside back cover

Carbon-Graphite—Catalog 55, 11pp, describes material used for mechanical applications. Pure Carbon Co., Inc., St. Marys, Pa.

Circle 159, inside back cover

Glass Fiber Moldings—Catalog, 16pp, describes custom molding services, mechanical, electrical and chemical properties. Molded Fiber Glass Co., 4403 Benefit Ave., Ashtabula, Ohio.

Circle 160, inside back cover

Position Encoders—Bulletin, 8pp, describes 13-digit and 16-digit optical-type analog-to-digital angular position encoders. Baldwin Piano Co., 1801 Gilbert Ave., Cincinnati 2, Ohio.

Circle 161, inside back cover

Silicone Products—Brochure, 8pp, has specifications on Silicone compounds available and data on properties of Silicone Rubber. Raybestos-Manhattan, Inc., Passaic, N. J.

Circle 162, inside back cover

Servo Motors—Catalog pages (4) describe low inertia instrument-type motor available in size 10. John Oster Mfg. Co., Racine, Wis.

Circle 163, inside back cover

Plastic Pipe and Fittings—Bulletin, 6pp. describes two types of unplasticized polyvinyl chloride pipe and fittings. Carpenter Steel Co., Union, N. J.

Circle 164, inside back cover

Magnetic Tapes—Booklet, 12pp, covers physical and magnetic properties. Minnesota Mining & Mfg. Co., Dept. A6-114, St. Paul, Minn.

Circle 165, inside back cover

Fasteners—Catalog, 30pp, has tables showing size ranges and specifications

(Continued on page 329)

Stop Aluminum Corrosion!

Insure Paint Adhesion

Provide Ornamental Finish

TURCOAT 4178

(Aluminum Surface Conversion Coating)

DOES ALL THREE!... Fixes Immediately, Too

Here's a process that provides *aluminum* with an ornamental, paint-gripping, corrosion-resistant coating... and does it faster and better!

Turcoat 4178 works on the surface conversion principle... that is, the coating is partially derived from the metal itself. Thus, coating and metal are *firmly interlocked*... even in tiniest crevices. The coating is a light golden color that imparts a special beauty when used for decorative purposes.

One user reports that square footage processed has *doubled* since the installation of Turcoat 4178. Key to this speed is the manner in which the coating "sets" and becomes non-smearing immediately. Drying is unnecessary. Parts can be further processed *without any delay in production!* Moreover, the coating is *uniform*. There are no light, tell-tale untreated sections around welds, corners or holes.

The Turcoat 4178 Coating becomes non-smearing immediately upon withdrawal from processing. Drying is unnecessary. Parts can be handled freely **while still wet** without danger of smearing or streaking coating.

MEETS GOVERNMENT SPECIFICATION

Meets Government Specification MIL-C-5541.

EASY TO CONTROL

Simpler titrations... Great latitude in solution strength. Eliminates need for constant complicated control.

EASY TO USE

Apply by immersion, spray washer or hand methods. Gold color gives visual control over processing.

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TURCO PRODUCTS, INC.

Chemical Processing Compounds

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Factories: Newark, Chicago, Houston, Los Angeles

Offices in all Principal Cities

Write for detailed technical literature.

Please affix coupon to company letterhead.

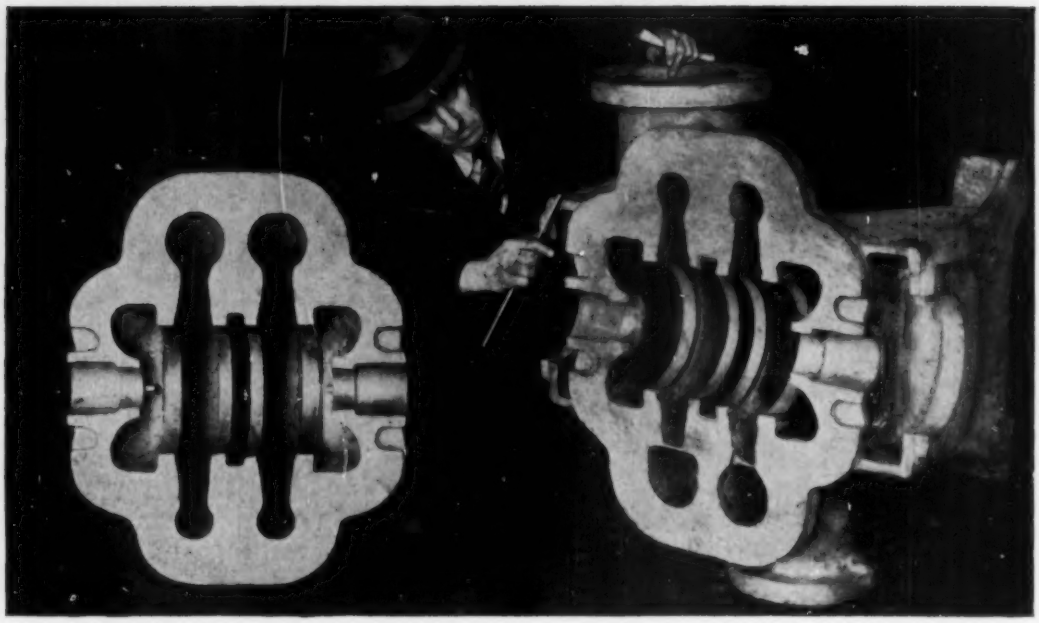
TURCO PRODUCTS, INC.
6135 S. Central Ave., Los Angeles 1, Calif.

Please send me detailed technical information on Turcoat 4178.

NAME_____

TITLE_____

Manufactured in Canada by B. W. Deane & Co., Montreal



There's NO problem in Stainless Castings that we can't answer for you—

Write for this book on AL STAINLESS STEEL CASTINGS

32 pages of valuable and complete data on stainless castings: analyses, properties, technical data on handling and heat treatment, typical applications, how to order, etc.

ADDRESS DEPT. PE-79

Odd shapes or intricate sections are certainly no problem—look at some of our stainless steel casting products illustrated above. We could show you hundreds more. And size is no consideration, either—we're equipped to handle any stainless castings—from a few ounces to thousands of pounds.

The really important point for you to consider is not the matter of shape or size, but of *experience.* The AL Buffalo Foundry is a group of specialists in high-alloy steel castings *exclusively* . . . pioneers in both the static and vertical-centrifugal methods of casting stainless steels.

For your assurance, there's a long record of years of successfully answering difficult service conditions with sound, clean-grained AL Stainless Steel castings—free from defects, easy to machine and dependable in supply. ● Let us quote on *your* stainless casting requirements. *Allegheny Ludlum Steel Corporation, Henry W. Oliver Building, Pittsburgh 22, Pennsylvania.*

WSW 5005 B

For Stainless Steel in ALL Forms—call

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Warehouse stocks carried by all Ryerson Steel plants

AL STAINLESS STEEL

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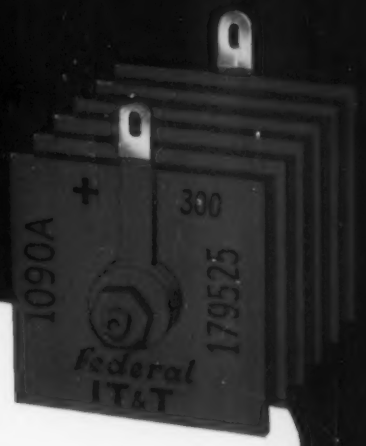
THE SELENIUM RECTIFIER
WITH THE GREATEST



Manufacturer Acceptance

More design and component engineers in the radio-TV industry have placed their approval on Federal Selenium Rectifiers than any other make—

And HERE'S why— point by point:

- **LONGER LIFE**... 5,000 hours life expectancy in approved applications.
- **HIGHER OUTPUT VOLTAGE**...3 to 6½ higher B+ output volts than competitive selenium rectifiers in conventional doubler circuits.
- **LOWER TEMPERATURE RISE**...2° C to 10° C lower average operating temperature than competitive selenium rectifiers.
- **SUPERIOR HUMIDITY RESISTANCE**... passes 1,000-hour life test in 95% relative humidity at 40° C.
- **PROVEN MECHANICAL CONSTRUCTION**... brass eyelet or aluminum stud construction used exclusively. Patented "dead-center" construction allows stack to be tightened until rigid, without affecting the pressure-sensitive selenium characteristic.
- **UNDERWRITERS LABORATORY ACCEPTANCE FOR 85° C OPERATION**... Federal's popular radio-TV types have been tested and accepted by UL for operation at cell temperatures of 85° C.
- **CONSERVATIVE RATINGS**...rectifiers offered to the industry are rated only after exhaustive temperature rise and aging tests on minimal grade units to insure full value and satisfaction.
- **MORE UNIFORM QUALITY**...Federal rectifiers are automatically 100% tested and inspected to meet standard forward and reverse current specifications, as well as for dielectric strength.
- **LARGEST PLANT CAPACITY**...production facilities to satisfy any quantity requirement.
- **MORE ENGINEERING KNOW-HOW**...the research and design facilities of the world-wide, American-owned International Telephone and Telegraph Corporation assure continued product leadership.

For full information, write Dept. F-642A

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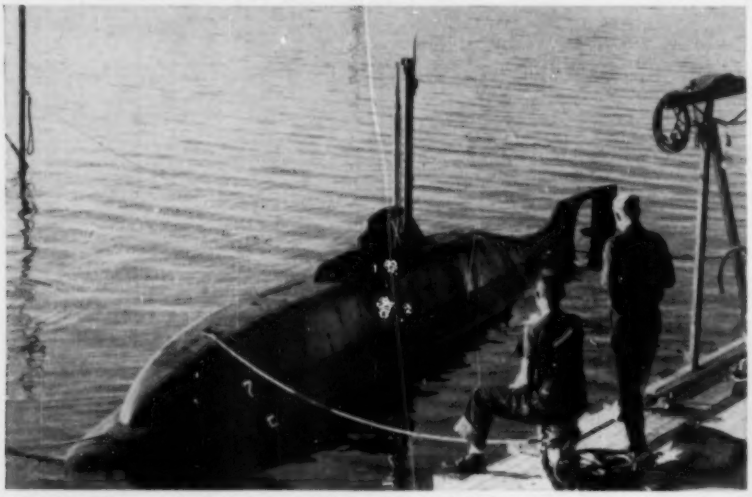
A Division of INTERNATIONAL TELEPHONE AND TELEGRAPH CORPORATION
COMPONENTS DIVISION • 100 KINGSLAND ROAD • CLIFTON, N. J.
In Canada: Standard Telephones and Cables Mfg. Co. (Canada) Ltd., Montreal, P. Q.
Export Distributors: International Standard Electric Corp., 67 Broad St., New York

★ Control Components Digest ★

News and notes on resistors, rheostats, relays, motor controls, dimmers and other control components



FIRST TEST DIVE, on a leash, for new midget sub. Fairchild engineers stand by. She passed this and other tests and was turned over to Navy.

New 4-man midget sub joins Navy

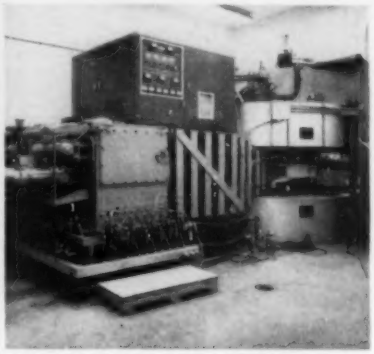
Only 50 feet long, but packing a mighty wallop, the USS X-1, a new midget submarine has just been preliminarily accepted by the U. S. Navy from the builders, Fairchild Engine Division of Fairchild Engine and Airplane Corporation, Deer Park, Long Island.

The 25-ton X-1 carries a 4-man crew, can dive under or cut through steel nets protecting harbors, and sneak up rivers and canals to attack power plants, bridges and dams.

And, among the many design features contributing to the striking power of this new Naval weapon, you'll find reliable Ward Leonard controls for the electric drive—just one of the ways Ward Leonard products are aiding national defense.

75-ton shield door gets fingertip control

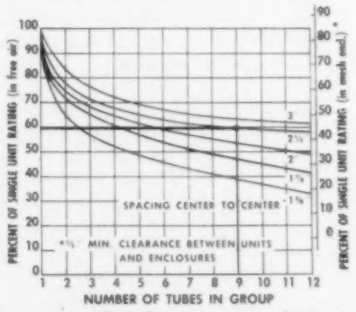
Centralized Ward Leonard motor controls slide the massive shield door for this modern cyclotron into place for research experiments at Brookhaven National Laboratory, Upton, Long Island, N. Y.



Made of concrete with steel support, and weighing 75 tons, the 5- by 8- by 12-foot door protects personnel from effects of radiation when deuterons (the nuclei of heavy hydrogen) are accelerated to an energy of 20 million electron volts.

Easy derating for group-mounted resistors

This family of curves will help the designer allow for mutual heating of resistors mounted in close proximity. It's typical of the practical design data you'll find in Ward Leonard's 65-page Catalog 15. Write for your free copy today. 6.8


PERCENT OF SINGLE UNIT RATING (in free air)
PERCENT OF SINGLE UNIT RATING (in mesh enc.)
SPACING CENTER TO CENTER
MIN. CLEARANCE BETWEEN UNITS AND ENCLOSURES
NUMBER OF TUBES IN GROUP

100% inspection here!

No statistics, no probability theory in this 100% check! She's measuring OD and concentricity of ceramic resistor cores—just two details in Ward Leonard's rigorous and continuous quality control. But, it's checking details like these on every single unit that gives Ward Leonard products their reputation for accuracy, stability and long life.

BAS ⁝ COMPONENTS for new dimming system.

New 500-to-1 dimmer for fluorescents

A new Ward Leonard dimming system for hot-cathode 40-watt T-12 fluorescent lamps handles up to 140 lamps with a dimming range of 500 to 1. Simple and non-electronic, the new dimmer is designed for control of cove lighting, luminous ceilings and multiple lamp fixtures in theatres, auditoriums, churches, offices, restaurants, and night clubs. Dimmer circuit output is unaffected by change in connected lamp load. For complete data, write for bulletin 76F.

WARD LEONARD ELECTRIC COMPANY
63 SOUTH ST., MOUNT VERNON, N. Y.
Result-Engineered Controls Since 1892
RESISTORS · RHEOSTATS · RELAYS · CONTROLS · DIMMERS

such as number of threads per inch, length, and quantities per package for socket head cap screws in regular, giant and microsizes. Standard Pressed Steel Co., Box 545, Jenkintown, Pa.

Circle 166, inside back cover

Knitted Wire Products–Bulletin A-1, 8pp, describes applications. Alloy Metal Wire Div., H. K. Porter Co., Inc., Prospect Park, Pa.

Circle 167, inside back cover

Subminiature Connectors – Bulletin D-6, 8pp, contains photographs, dimensional data, soldering, mounting and shell deviations. Cannon Electric Co., Catalog Department, 3208 Humboldt St., Los Angeles 31, Calif.

Circle 168, inside back cover

Wire-Wound Resistors–Bulletin D-1a, 4pp, has data on winding techinque, testing, tolerance, inductance, insulation, terminals, temperature coefficient. International Resistance Co., 401 N. Broad St., Philadelphia 8, Pa.

Circle 169, inside back cover

Planetary Gear Transmissions–Booklet, 8 pp. describes seven different models of transmission for application to road building equipment, lift-trucks and similar equipment. American Gear & Mfg. Co., New Ave., Lemont, Ill.

Circle 170, inside back cover

Letterhead Requests Only

Manufacturers who published following literature ask that requests for copies be made on company letterheads.

Graphite For Atomic Reactors–Book, 61 pp, is a complete printing of a paper presented at the UN International Conference on Peaceful Uses of Atomic Energy, Geneva, Aug. 8-20, 1955. Information is presented on the production of artificial graphite in the electric furnace, the effects of raw materials and processing variations, and three chapters are devoted to the physical, mechanical, and chemical properties. National Carbon Co., 30 E. 42 St., New York 17, N. Y.

Sheet Metal Weight Calculator–Instead of calculations being made per square foot weight, this slide rule gives the weight per lineal foot in any size width of sheet metal. Dayton Rogers Mfg. Co., Minneapolis 7, Minn.

THE SHAPE OF THINGS IN MOLDED RUBBER

MOLDED LIFE GUARD
KEEPS SWITCHES FROM DROWNING

APPLICATION:
Water seal for push button switches on top brand washing machine.

PROBLEM:
Compound a rubber stock that will provide a molded part with good electrical resistance and be able to withstand deteriorating action of soap and detergents. Produce a molded part that would effectively seal push buttons from water without restricting switch movement.

SOLUTION:
The small openings for switch buttons posed a very definite problem. The contours of openings had to allow buttons to move freely and at the same time provide a perfect seal (shown in close-up). Acushnet laboratory technicians first produced a dipped part to experiment with the flash of rubber around the switch area. Natural rubber was selected for maximum flexibility and to provide excellent hot tear resistance, an essential quality in the molding of this special part. For the sake of economy a compression mold of sintered metal with a solid steel core made possible a flash extension fit of .050" resulting in a precision fit over the switch buttons after the dieing out finishing process. This mold, designed and built by Acushnet, aided in economically producing a high quality part that passed the Underwriter's Laboratory tests.

Acushnet's exclusive facilities for accurate compounding, engineering and precision molding of rubber, silicone and silicone resin parts can aid you with your next problem at any stage of design.

Send for Acushnet "Rubber Data Handbook."

What's Your Shape?

Acushnet

ACUSHNET PROCESS COMPANY
NEW BEDFORD, MASSACHUSETTS

... *Precision Molded* RUBBER, SILICONES - "APCOTITE" BONDING

Address all communications to 768 Belleville Ave., New Bedford, Mass.

New Taylor Copper-Clad Laminates

now available in production quantities

Why Taylor Copper-Clad Laminates Help Capitalize the Full Potential of Printed Circuits . . .

Taylor's ability to use high purity rolled copper—in weights of one, two or three ounces per square foot—assures production of materials that will more satisfactorily meet industry's needs because...

Rolled copper surface is smoother (freer from pits, pinholes and imperfections) . . . more uniform thickness . . . no sacrifice in conductivity. Result: Consistently satisfactory etching at better production rates.

After months of research and experimentation, Taylor is now in production on two brand new copper-clad laminates that give you opportunity to realize—on a sound basis—the full potentials of printed circuit construction.

Produced by an exclusive Taylor process that permits the use of readily available, high purity rolled copper, these laminates are supplied in two grades—XXXP-242 Copper-Clad, with a premium quality phenol paper base material; and GEC Copper-Clad, with a superior epoxy glass base material.

Taylor makes both of these copper-clad laminates in sheets approximately 37 x 49 inches . . . in thicknesses from .015 to .25 inches . . . with copper on one or both sides.

Whatever your experience with copper-clad laminates . . . whatever your ideas on the subject . . . it will be to your advantage to find out just what the new Taylor materials can do for you. Contact the nearest Taylor sales engineer . . . for more information or for your sample order.

Taylor GEC Copper-Clad provides . . .

- Superior electrical and mechanical qualities for critical applications.
- High electrical stability over wide humidity range.
- High resistance to dip soldering temperatures up to 500 F.
- High insulation resistance and surface resistivity after etching.
- Ready punchability.
- Good, uniform copper-to-laminate bond strength.

Taylor XXXP-242 Copper-Clad provides . . .

- Cold punchability. For intricate punchings—warm to 150 F. max.
- High resistance to dip soldering temperatures up to 500 F.
- High insulation resistance and surface resistivity after etching.
- Translucence. Permits easy checking of circuit alignment on opposite side.
- Good, uniform copper-to-laminate bond strength.

TAYLOR FIBRE CO. Plants in Norristown, Pa. and La Verne, California

Branch Offices

Atlanta	Detroit*	Philadelphia
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*Teletypewriter service at both plants and these branches.

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Laminated Plastics
Vulcanized Fibre

Neither underpowered nor overpowered—
that's because each of these units is equipped with a right-for-the-job Chrysler Industrial Engine.

Power shovels, for example, require a lot of power plus something extra when occasion demands. Chrysler supplies the 331 cubic inch displacement Ind. 56 Engine for regular power requirements plus the dual-cooled Chrysler Industrial Torque Converter for stepped up torque as needed.

Transit mixers, industrial lift trucks and towing tractors may not require as much torque as the shovel; however, they do need protection against the wear and tear of stop and go operation. Chrysler Ind. 30 Engine gives them 230 cubic inch displacement and Chrysler gyrol Fluid Coupling prevents shock loads, engine stalling and lengthens life of engine, drive and equipment.

perfect power for any application!

Ditchers, farm combines, loaders, orchard sprayers — whatever power they need, there's a Chrysler Industrial Engine to supply it. If the unit also requires power takeoff, mechanical or velocity governor, 3, 4 or 5-speed transmission, propane or natural gas burning carburetor, Chrysler can supply these and many other accessories, factory-installed.

Don't let power stall your plans. Check specifications against your requirements. Then see your Chrysler Industrial Engine Dealer — find him in the Yellow Pages of your telephone book under "Engines-Gasoline" — or write direct for catalog: ***Dept. 37, Industrial Engine Division, Chrysler Corporation, Trenton, Michigan.***

SPECIFICATIONS—CHRYSLER INDUSTRIAL ENGINES

	Ind. 30	Ind. 31	Ind. 32	Ind. 33	Ind. 52	Ind. 56
No. of Cylinders	6	6	6	6	8	8
Type of Engine—4 Cycle	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline
Bore—Inches	3¼	3¼	3 7/16	3 7/16	3 7/16	3 13/16
Stroke—Inches	4⅛	4⅛	4¼	4¼	3¼	3⅛
Displacement—Cu. In.	230	230	265	265	270	331.1
Compression Ratio	7.0	7.0	6.8	6.8	7.5	7.5
Valves—Arrangement	L	L	L	L	OHV	OHV
Camshaft Drive	Silent Chain	Gear	Silent Chain	Gear	Silent Chain	Silent Chain
Engine Width*	23 1/16"	23 1/16"	23⅛"	23⅛"	30⅛"	28 13/16"
Engine Length*	32 5/16"	31 13/32"	32 19/32"	33 1/16"	29 31/32"	31 1/32"
Engine Height*	34½"	32 27/32"	32 29/32"	32 29/32"	34¼"	34 23/32"
Engine Weight*	575 lbs. (approx.)	610 lbs. (approx.)	740 lbs. (approx.)	760 lbs. (approx.)	712 lbs. (approx.)	845 lbs. (approx.)

*Dimensions vary with equipment. Specifications subject to change without notice.

CHRYSLER

industrial engines

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INDUSTRIAL ENGINE DIVISION • CHRYSLER CORPORATION

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TODAY'S EMPHASIS is on speed — both in domestic appliances and industrial applications. Mica is a wonderful insulating material. It has ample mechanical strength, will not react with resistor substances and is unaffected by oils or organic solvents. It will not crack under extreme temperature changes nor lose its dielectric value.

COMMUTATOR MICA INSULATION

Molding Plate — Segment Plate — Mica Rings — Mica Segments — Mica Bushings

Class B and Class H

For all types of starting and generating motors

Accurate to specified dimensions

Properties controlled to assure fullest efficiency of assembly and operation of commutators

FLEXIBLE MICA & COMPOSITES

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Sheet, roll and tape forms

Formed slot liners

MICA TUBING

Round, square, rectangular

Class B and Class H

Specified dimensions

COIL & SLOT INSULATION

Molded or formed to specified dimensions

Y-26 HIGH HEAT MICA

Completely inorganic. Combines the durability, high electrical insulation value, temperature resistance and high reflective value. It is available in large sheets, 16" x 36" and 16" x 50". Pieces stamped to your exact specifications.

Tell us your area of interest and we will send you large samples for testing — or, better still, send your drawings for quotation and learn how you too can have better insulation at lower cost.

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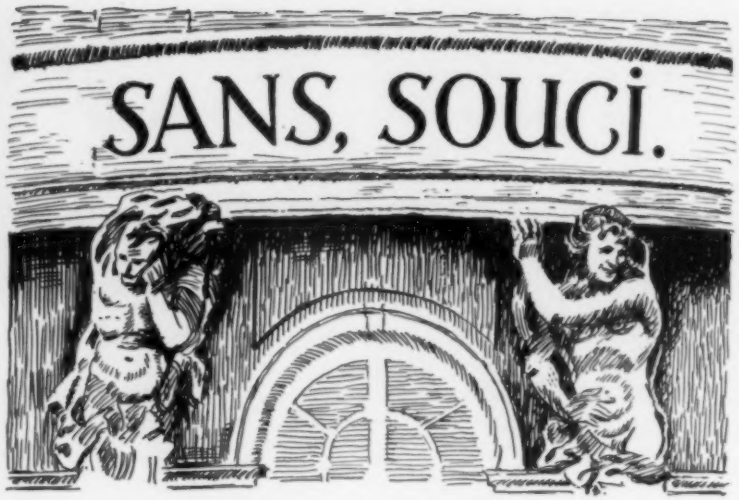
INCORPORATED
Waltham 54, Massachusetts



Ad Libbing by the Editor

One of the pleasures of writing this Sans, Souci column is the correspondence that I get from the readers. Because the column is written "sans souci," that is, "without care," it follows that there will be errors of omission and commission. Hence the letters from the readers.

Along that line, Charles J. Poth of Pittsburgh wrote me, "The article Sans, Souci on page 387 in your April issue states that, 'The shots that killed the strikers at Homestead Steel. . . .' I think if your writer, (meaning me) will look into this matter carefully he will find that the people who were killed were the armed guards. Admittedly it was a very vicious strike."

This is one of those happy instances in which both parties to the question are both right and wrong.

I must confess that the incident was written entirely from memory. About twenty years ago I delved into the detailed report of the Congregational Investigation of the Homestead Strike. So as soon as I got Mr. Poth's card I decided to refresh my memory. I found the answer in the book "History of the Labor Movement in the United States" written by Philip S. Foner, published by the International Publishers of New York City. I believe the price is $5.00. In Volume II of this extremely well written book, beginning on page 206, the author presents in detail the whole story of the deplorable Homestead Strike.

The author, Dr. Foner, obtained his material from the manuscript sources of the A.F. of L. headquarters, the papers of Terence Powderly who was General Master Workman of the Knights of Labor and Father Henry J. Browne of the Catholic University of America. He also went to innumerable other sources, collecting manuscripts, newspaper clippings and pamphlets.

Dr. Foner is a graduate of the College of the City of New York, has a Ph.D. from Columbia University, is a member of Phi Beta Kappa, taught history at the College of the City of New York. He is a scholar and a teacher.

Beginning on page 206 of Volume II of his book, Dr. Foner tells the story of "The Homestead Strike." It makes extremely interesting reading. I will present only a very sketchy outline of the author's presentation. The book tells the story far better.

In effect, the Carnegie Steel Company had a labor contract with their men which was to expire on June 30, 1892. Henry Clay Frick had recently been put in control of the Carnegie Steel Company. He was a notorious anti-union manager operating under Andrew Carnegie. Frick immediately got into a tussle with the union which operated under the name of the Amalgamated Association. The majority of the employees of the Carnegie Homestead plant were non-union.

Carnegie Steel Company offered a contract to the men which was extremely unsatisfactory to them because it involved drastic reductions in pay. The workers rejected the proposals and the company on the evening of June 29, 1892 shut down the

(Continued on page 337)

NOW FOR THE FIRST TIME

AJAX 3-D Degree

DIHEDRAL COUPLINGS

NTRODUCE TRULY SELF-ALIGNING COUPLINGS

at no extra cost

NEW Ajax 3-D Dihedral Couplings are self-
igning to 3 degrees, yet cost no more than
dinary gear type couplings.
ney are designed and built on the same prin-
ple used in the D-100 Series Ajax Dihedral
oupling introduced 5 years ago.

The success story of Ajax Dihedral Couplings created an insistent demand for a coupling providing Ajax Dihedral performance on direct-connected equipment where misalignment does not exceed 3 degrees.

Features of the new Ajax 3-D Dihedral Coupling include:

3 degree misalignment capacity.

Load is distributed at center of teeth at the point of greatest strength.

More tooth strength is provided under misalignment than is possible with any other tooth shape.

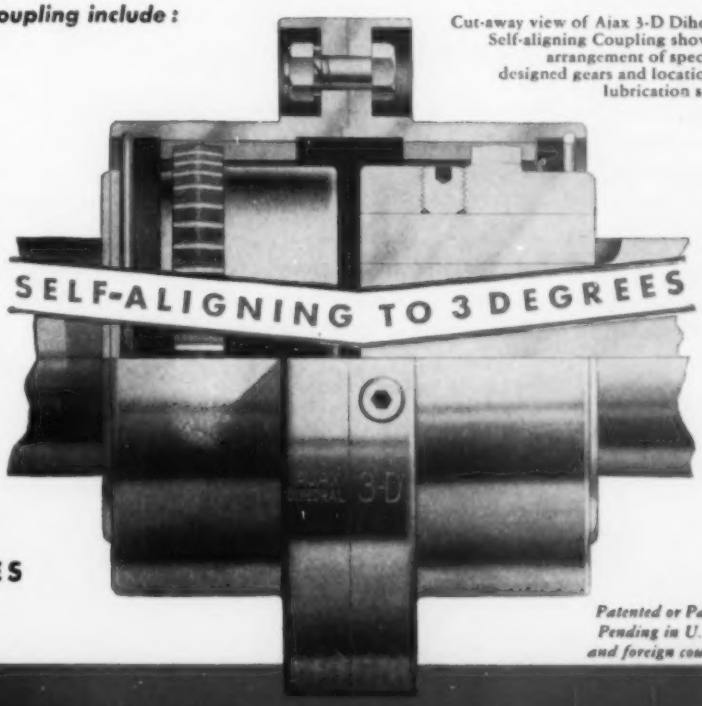
Exclusive Ajax Dihedral tooth design has less clearance than conventional gear type couplings.

No end-of-tooth wear under misalignment. Johns-Manville "Clipper" seals keep lubricant in and foreign matter out.

Compact overall size.

Designed for NEMA motors with standard keys.

Low prices competitive with ordinary gear type couplings.



Cut-away view of Ajax 3-D Dihedral Self-aligning Coupling showing arrangement of specially designed gears and location of lubrication seals.

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UNLIMITED OPPORTUNITY in the broad, ever-expanding field of Business Machine Engineering and Research.

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A RECREATIONAL PROGRAM for year-round enjoyment for the entire family, including a new NCR Country Club with 36 holes of golf, and a 166-acre employees' park for outings with swimming, boating and supervised play for children.

LIVING IN DAYTON—an attractive, progressive city with outstanding school facilities.

YOUR WORK AT NCR with its friendly, family atmosphere, where you work with people who, like yourself, have decided to build their professional future with NCR.

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- **Send resume of**
- **your education, experience**
- **and geographic preference to:**
- **Employment Department,**
- **Professional Personnel Section 2**

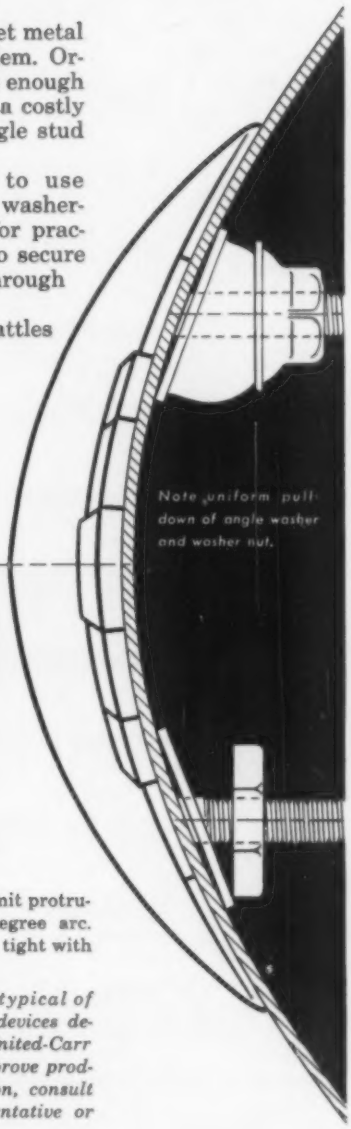
THE NATIONAL CASH REGISTER COMPANY • DAYTON 9 • OHIO

DOT's new angle washer holds cast trim against curves

Fastening die-cast trim to curved sheet metal surfaces can be a troublesome problem. Ordinary nuts jam before they get close enough to hold tight. One solution has been a costly mould construction permitting off-angle stud casting.

The modern cost saving way is to use United-Carr's new angle washer and washer-nut combination. This compensates for practically any curve or can be used to secure studs that protrude at an angle through a flat surface.

Tight fastening is assured and rattles never get a chance to start.



Light, strong metal shell is slotted to permit protrusion of stud at any angle within 45 degree arc. Washer nut matches shape of shell, locks tight with normal wrench torque.

The angle washer and washer nut are typical of thousands of special-purpose fastening devices designed and manufactured in volume *by United-Carr to help speed assembly, cut costs and improve product performance. For further information, consult your nearest United-Carr field representative or write us for his name and address.*

UNITED-CARR Fastener Corp.

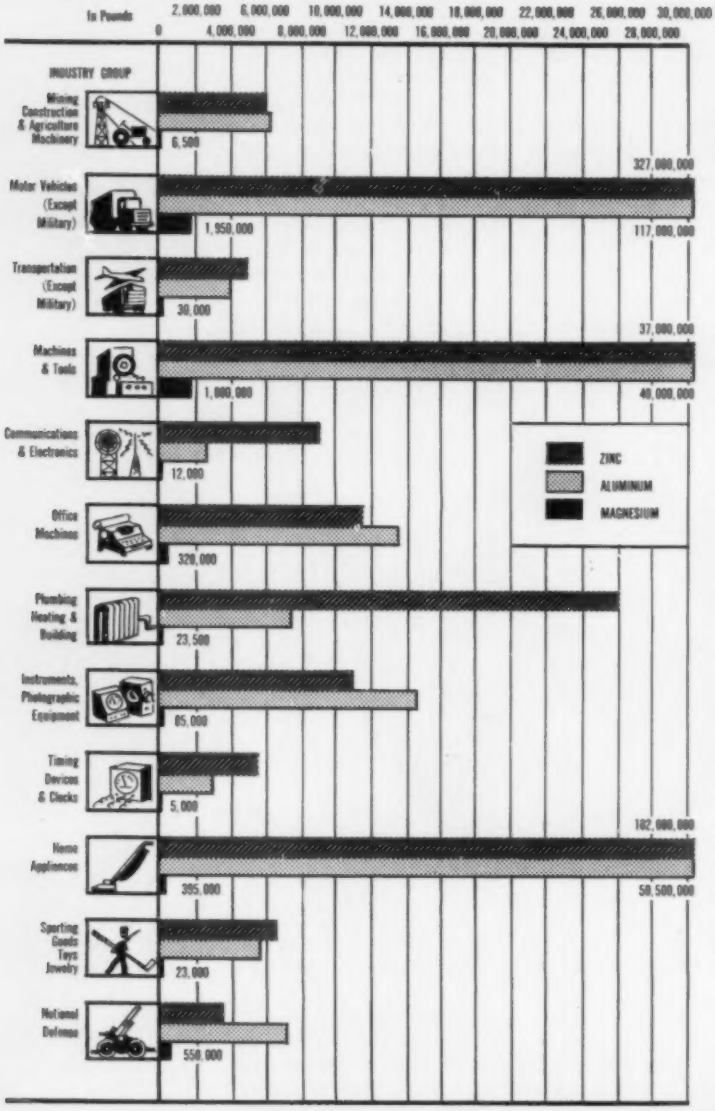
31 Ames Street, Cambridge 42, Mass.

MAKERS OF DOT FASTENERS

WHO BUYS DIE CASTINGS?

These Industries Do!

END USE DISTRIBUTION OF DIE CASTING SALES IN 1955 Totals represent all job shop sales. Captive use not included. Source: Reports of members to American Die Casting Institute.



Last year set all-time high records for die casting production and sales. Substantial increases in the use of die castings by the industry's major customer groups indicates that when design engineers are faced with the competitive challenge of keeping quality high and prices low, more often than not the die casting process provides the solution.

Consumption of zinc for die casting is estimated at 410,000 tons – 40% of total slab zinc production. Shipments of zinc die castings by job shop, or custom, producers represented some 67% of the zinc die casting metal consumption totals. The balance represents captive production by end-product manufacturers. 99.99+% metal – which is the grade on which all zinc die casting alloys are based – exceeded any other grade in total consumption, displacing Prime Western last year for the first time in history. Most important of all, the use of zinc die castings increased in 8 of 11 industry groups. In industry's efforts to keep quality high and prices low, the relatively young die casting process has become a major factor. It is inevitable, therefore, that the consuming industries will require more and more Special High Grade Zinc. As pioneers in its production, Bunker Hill is now taking steps to make greater tonnages of 99.99+% metal available.

DIE CASTING is the Process • ZINC, the Metal

BUNKER HILL, the Preferred Zinc

BUNKER HILL 99.99+% ZINC

EASTERN SALES AGENTS ST. JOSEPH LEAD COMPANY 250 PARK AVENUE, NEW YORK 17

SALES OFFICE FOR PACIFIC COAST NORTHWEST LEAD COMPANY SEATTLE, WASHINGTON

great steel mill at Homestead. The fight began.

It appears that a vast majority of the workers very soon swung over to the union and joined the Amalgamated Association or at least stood by the Amalgamated Association. The union immediately organized to fight the strike in a big way. The entire labor force of 3,800 men, skilled and unskilled, union and non-union, native and foreign born, joined hands against the company.

The union picketed the plant which was located on the banks of the Monongahela River and they hired a steam launch plus a number of skiffs to patrol the river day and night, to prevent the company from getting strike breakers into the plant.

In the meantime, the company had hired the Pinkerton Detective Agency to furnish 300 guards who were to be brought into the plant at night via barges proceeding up the river. The Pinkerton Detectives wore uniforms and were armed with Winchester rifles. The strikers found out all about it the day before.

It was probably one of the most dramatic and regrettable strike incidents that has ever occurred. The townspeople rushed to the river bank. The strikers' steam launch, Edna, paddled down the river to meet the "foe," along with smaller craft of the strikers' "navy" trailing on behind. The crowd on shore kept pace with the boats and when the crowd came to the fence at the mill they broke it down and swarmed through the mill yard to the landing where the Pinkerton men were supposed to come ashore.

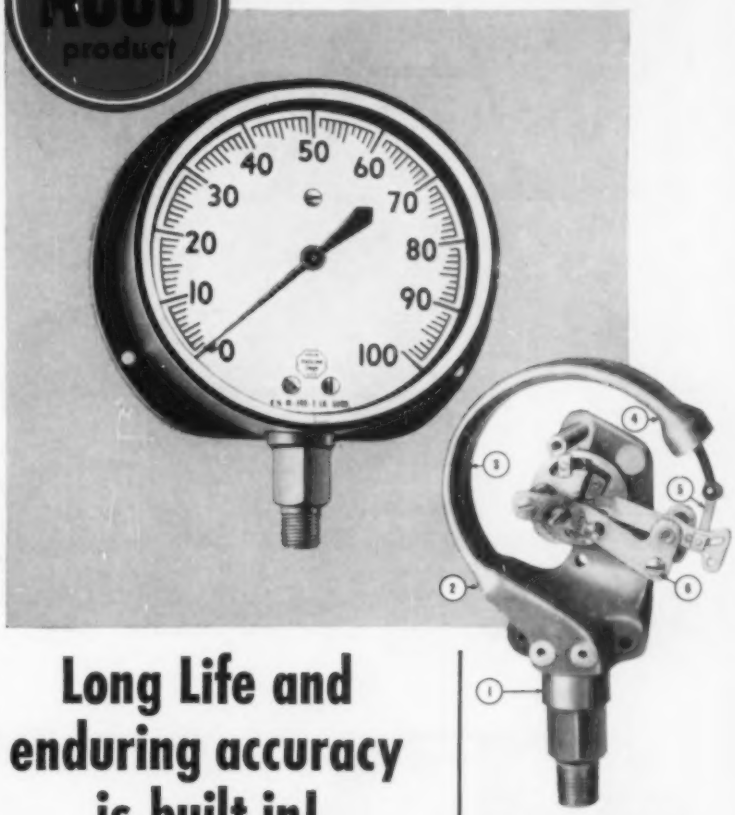
The workmen warned the Pinkertons back but the captain of the guards stepped out of the barges announcing they were taking over the works and that the crowd must leave. The detectives went ahead, put a gangplank ashore and several Pinkertons started down. A shot rang out and the fight began. Who fired the first shot has never been established. The battle lasted from 4:00 o'clock in the morning July 6th until 5:00 o'clock that afternoon. At least nine workers were killed and three of the Pinkertons paid with their lives for their attempt to take over the mill.

Finally the Pinkertons had to surrender and the workmen marched

(Continued on page 340)

an ACCO product

Helicoid Gages



Long Life and enduring accuracy is built in!

• Sustained accuracy of HELICOID Gages through years of hard service comes from superior design and construction.

The HELICOID Gage has many unique and exclusive features. It is not only a pressure instrument of the utmost precision but one that requires but a minimum of maintenance throughout a long service life.

The smooth rotation of the spiral movement and cam outlasts and outperforms other gage types. There are no gear teeth to wear out.

HELICOID Gages are available to meet every type of pressure indicating requirement. Ranges are from 15 to 20,000 p.s.i. and vacuum or compound.

Write for catalog today

Why HELICOID Gages last longer!

Socket (1) is one-piece drop forging, streamlined to reduce possibility of clogging.

Bourdon tube* (3) is alloy steel, stainless steel or K Monel.

Tube is welded to forged socket (2) and tip (4).

Connecting link and link screws (5) are K Monel.

Helicoid movement (6) is corrosion resistant.

*Phosphor bronze tube also available.

ACCO

Helicoid Gage Division
AMERICAN CHAIN & CABLE

929-D Connecticut Avenue • Bridgeport 2, Connecticut

for Better Value

A

AB

B

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What Type American Are You?

It takes a lot of different types of people to make America what it is. And it takes different types of blood to make a blood bank . . . each as important as the other . . . each needed desperately.

Before the next 60 seconds have ticked away, four Americans will need blood to save their lives.

Give blood today . . . and save a life tomorrow!

the blood you give helps someone live!

GIVE BLOOD NOW

NATIONAL BLOOD PROGRAM

PESCO REPORTS ON:

tomorrow's aircraft accessories

In well-equipped laboratories, in busy engineering offices, PESCO's "mind-power" is hard at work perfecting design concepts for tomorrow's aircraft accessories. These will be vital elements of the jet, rocket and nuclear-powered aircraft now being planned to meet the challenge of the Atomic Age.

This is a progress report from PESCO on what the future may hold for aircraft accessories.

ADVANCED DEVELOPMENTS

In development or preliminary design at PESCO are such unique products as pumps for propellants and special fuels—hydrogen peroxide, ethylene oxide, nitric acid, propyl nitrate and others; pumps for circulating liquid metal nuclear coolant; an electro-hydraulic nuclear control rod mechanism; electro-hydraulic servo transfer valves; and air and gas turbine drives.

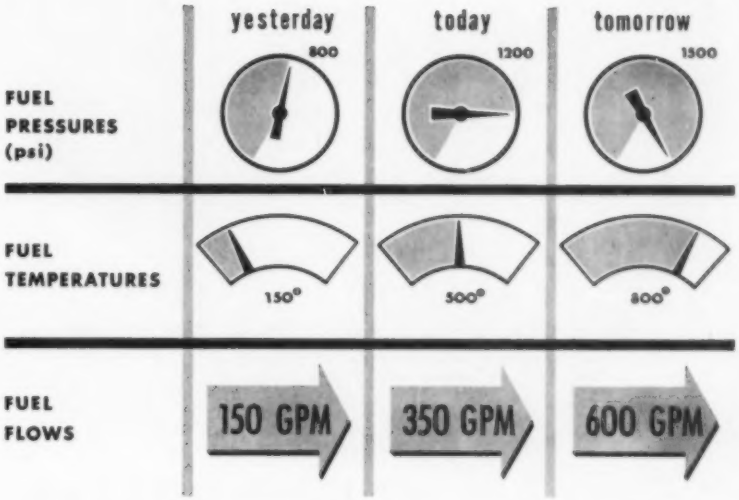
Never content, PESCO engineers have set their sights on some eye-opening performance standards. For aircraft of the future, they foresee fuel pumps that will operate at fuel temperatures of 800° . . . pressures of 1,500 psi . . . and flows to 600 gpm. Propellant pumps will provide capacities to 5,000 gpm, nuclear coolant pumps will handle 15,000 gpm (see illustration).

DEVELOPMENT FACILITIES

Development of tomorrow's aircraft accessories will require extensive physical laboratory facilities . . . and PESCO has planned for this. At present, PESCO has: Hydraulics Laboratory, Fuel Laboratory, Electrical Laboratory and Materials Laboratory. By 1957, PESCO will have added a High Temperature Fuel Laboratory, a High Temperature Hydraulics Laboratory and a Propellant Laboratory. Longer-range plans call for an Advanced Propellant-Nuclear Coolant Laboratory. In addition, PESCO has available the central research facilities of its parent firm, Borg-Warner Corporation.

CURRENT DESIGN PROGRAMS

Active prototype development work is now well-advanced on main engine fuel pumps for almost all major aircraft engines including the most advanced turbojet, turboprop and gas turbine models.



Projected performance characteristics for tomorrow's aircraft fuel pumps.

Equally vital are afterburner pumps for the turbojet engines which require them. Fuel booster pumps are being engineered for many planes and include such recent PESCO advances as line-mounted and plug-in types. Other projects include variable displacement hydraulic pumps and hydraulic motors.

CURRENT PRODUCTION

PESCO is more than a forward-looking development engineering organization—PESCO experience qualifies it as a top source for aircraft accessories. From PESCO production lines, the aircraft industry is now getting jet engine fuel pumps, fuel booster pumps, fuel flow controllers, hydraulic pumps, air and vacuum pumps, axial flow blowers, pilot's pressurization suit air conditioning packages, fuel valves, hydraulic valves and electric motors.

WHERE PESCO CAN HELP

With its engineering skills and technological resources, PESCO stands ready to help you with your new product design problems. If they involve the control or transmission of any pressurized materials, from air to liquid metals, our engineering staff will be glad to discuss them with you.

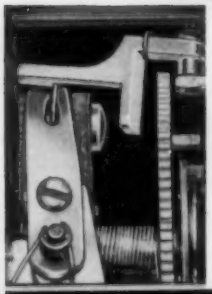
To develop *tomorrow's aircraft accessories* the alert, far-sighted technical group at PESCO is at the service of industry or government.

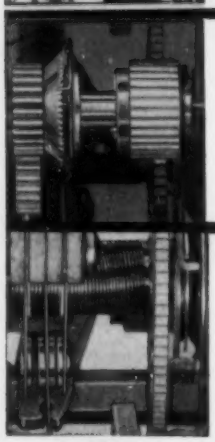
For *today's aircraft accessories*, PESCO is your most dependable source. For full information on PESCO services and products, contact your nearest PESCO sales engineer or write: PESCO, 24700 North Miles Road, Bedford, Ohio.

PESCO PRODUCTS DIVISION
BORG-WARNER CORPORATION
24700 NORTH MILES ROAD • BEDFORD, OHIO

Producing the Best in Hydraulic Pumps, Fuel Pumps, Electric Motors and Axial Flow Blowers

NEW!





CRAMER

automatic reset
INTERVAL TIMER

NEW—Full-vision 300° protected dial for fast, accurate readings.

NEW—Large friction setting knob with integral push button.

NEW—Repeat accuracy within ±1/3 of 1% of full scale.

NEW—15-amp. open-blade switches, positive quick-make, quick-break operation.

NEW—Multi-position terminal block offers wiring flexibility, side or rear connection.

Powered by the high-torque (30 in. oz. @ 1 r.p.m.) Cramer synchronous motor, the Type 241 Automatic Reset Interval Timer has been designed and tested to new standards for *maintained* accuracy over a long service life.
Available in ranges from 15 seconds through 24 hours.
Write for complete information.

SPECIALISTS IN TIME CONTROL

CRAMER CONTROLS CORPORATION
Formerly The R. W. Cramer Co., Inc.
BOX 7, CENTERBROOK, CONNECTICUT

15CR51

them from the barges to a skating rink in the town where they were kept. The workmen burned the barges and, "The battle of the Monongahela ended amidst the roaring blaze."

Today there stands a stone shaft at a street intersection in Homestead carrying this inscription: "'Erected by the members of the Steel Workers Organization Committee Local Unions, in memory of the Iron and Steel workers who were killed in Homestead, Pa., on July 6, 1892, while striking against the Carnegie Steel Company in defense of their American rights."

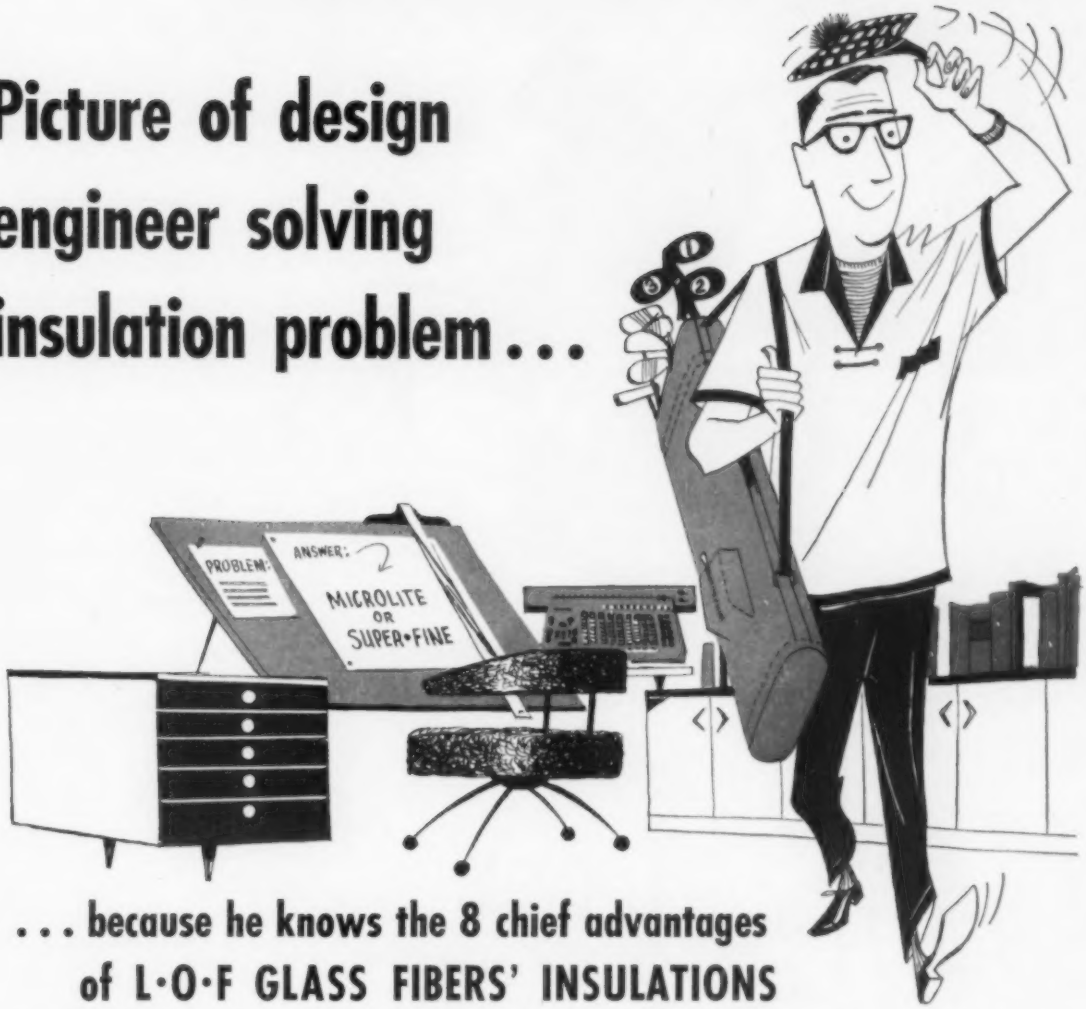
We Learn the Hard Way

We must bear in mind that this occurred more than sixty years ago. United States Steel Corporation and every other American company clearly recognizes that the whole affair was deplorable and that many of the things that were done by the company were fundamentally wrong and unjust. But in those days it was the only way that a company could operate and continue in business. During that year of 1892 there were many other bitter strikes involving railroad workers, coal miners, copper miners and others. But it was the bloody clash at Homestead that "aroused nationwide interest and international attention." And it did more than anything else for the labor unions and for elevating the standards of living of the American people. In the end, business also profited greatly.

When one evaluates the progress of civilization in its employer-employee relations, we find great men on both sides of the fence. Many people will consider the labor leaders to be greater because they had to fight for the "under dog." On managements' side we have great names such as George Eastman, Henry Ford, James Lincoln and a host of others. We find great leaders who render great service to mankind in all walks of life, in all human activities and in all income brackets and both in management and in labor.

It seems to require sweat, tears and blood to teach humanity its greatest and most valuable lessons. The charlatans can put across their wares by inane banter but the scientist and philosophers must suffer and perhaps die before their teaching are understood. —G. F. N.

Picture of design engineer solving insulation problem...



... because he knows the 8 chief advantages of L·O·F GLASS FIBERS' INSULATIONS

Because L·O·F Glass Fibers' Insulations solve so many insulation problems quickly and completely, they enable the design engineer to devote precious time to other pressing problems—even golf!

Both Microlite and Super·Fine—the two blanket insulations made by L·O·F Glass Fibers Company—provide high thermal efficiency and sound-absorption characteristics, plus these advantages:

1. LIGHT WEIGHT—It reduces weight of insulated units.
2. SPACE REDUCING—It does a better insulating job in less space than do most insulating materials.
3. HANDLES EASILY—because it's soft and pliable. Compresses readily into hard-to-reach spots; springs back to original shape. Has high tensile strength.
4. CLEAN AND SANITARY—because it is made of inorganic glass fibers.
5. RESISTS SETTLING—when subjected to constant bumps and jarrings.
6. FIRE-RESISTANT—Glass fibers are noncombustible.
7. MOISTURE-RESISTANT — Glass fibers are nonhygroscopic and noncellular. Should the glass fiber blanket come into contact with water, the glass fibers will not be injured.
8. EASY TO FABRICATE—Can be easily cut to any shape or size with knife or scissors, or on regular die-cutting equipment. Readily bent around curved surfaces and fitted into irregular areas.

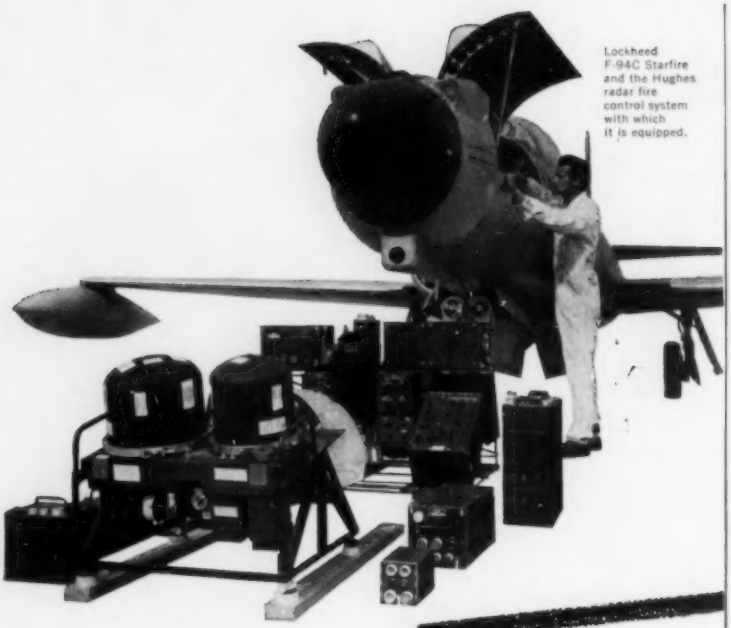
For further information on how L·O·F Glass Fibers' Insulations can help solve your design problems, contact our nearest sales office. Or write: L·O·F Glass Fibers Company, Dept. 4-76, 1810 Madison Avenue, Toledo 1, Ohio.

MICROLITE
L·O·F GLASS FIBERS
SUPER·FINE

L·O·F GLASS FIBERS COMPANY

TOLEDO 1, OHIO

Makers of glass fibers by the "Electronic-Extrusion" process



Lockheed F-94C Starfire and the Hughes radar fire control system with which it is equipped.

Hughes has been the leader from the beginning in applying electronic computers to airborne fire control equipment. Today every U.S. Air Force and Canadian continental defense interceptor uses Hughes-developed and Hughes-manufactured systems.

Product Design at

HUGHES WEAPON SYSTEMS DEVELOPMENT LABORATORIES

As the intercept problem becomes more and more automatic, additional equipment such as new-type computers, control surface tie-in (CSTI), autopilots, and other units must be integrated into the system. Faster speed and heavier engines dictate more streamlining—and hence less space for electronic gear. The result is even more miniaturization and compact packaging, evolved from special techniques.

This all means that now the product design engineer is more important than ever before. In the Product Design Laboratory he is a vital part of the formal link between the Research and Development activity and the optimum configuration and installation arrangements for the systems "black boxes."

HUGHES *Scientific Staff Relations*

RESEARCH AND DEVELOPMENT LABORATORIES

HUGHES AIRCRAFT COMPANY

Culver City, Los Angeles County, California

These positions in the Product Design Laboratory are open now in the Weapon Systems Development Laboratories:

IN THE GUIDED MISSILE AREA

ENGINEERS

to work on design and construction of microwave components.

ENGINEERS

to engage in the design and fabrication of airborne telemetering equipment for guided missiles.

ENGINEERS

to participate in development, design and prototype construction of electrical and electrohydraulic power supplies.

IN THE RADAR FIRE CONTROL AREA

ENGINEERS

to do equipment development and circuit design on special military field test equipment for support of fire control radar, fighter identification, and armament auxiliary equipment.

ENGINEERS

for circuit and equipment development in the field of airborne communication and navigation circuits.

ENGINEERS

experienced in computer or related fields to develop military field tests and auxiliary equipment for support of airborne computers.

You are invited to send resumes of your education and experience to the address at left.

VACATIONING IN SOUTHERN CALIFORNIA? YOU ARE INVITED TO VISIT HUGHES.

NOW THERE'S A BETTER WAY TO BUILD IT!

Three times stronger than carbon steel, new Lukens "T-1" steel makes equipment lighter and tougher!

■ With its outstanding yield strength and toughness, this remarkable alloy steel makes new concepts of equipment design possible. It has unusual resistance to abrasion, impact and atmospheric corrosion—and it *stays* tough at low temperatures. Because finished equipment can be made lighter as well as stronger, new Lukens "T-1" steel often means over-all savings in material costs.

Before you plan or buy *anything* made of steel plate, consider the effect of Lukens "T-1" steel on maintenance expense . . . replacement costs . . . daily performance. In these and many other ways, it is already delivering substantial economies to hundreds of users.

And this unique steel comes from Lukens in the widest range of plate sizes available anywhere!

For technical data and specific applications in your field, write to Manager, Marketing Service, 849 Lukens Building, Lukens Steel Company, Coatesville, Pennsylvania.

Whatever your plans—now's the time to change to . . .

LUKENS "T-1" STEEL

LUKENS

THE NEWEST IN A COMPLETE LINE OF ALLOY STEELS
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BARBER COLMAN Small Motors

Selected for fuel computers and indicator transmitters on Stanley Cockpit Procedure Trainers

Duplicating the operation of an actual jet plane in flight, Stanley Cockpit Procedure Trainers give Air Force student pilots intensive flight training right on the ground. These trainers realistically simulate such aircraft systems as the engines, engine controls, landing gear, flaps, surface trims, and fuel, electrical and hydraulic systems. To assure precision operation of fuel computers and indicator transmitters Stanley Aviation Corporation chose Barber-Colman OYAZ type reversible motors which are adaptable to a wide variety of control circuits. Compact, powerful, and fast-reversing, these highly dependable motors may be the solution to your control problems, too. Write for data.

the complete line of Barber-Colman motors includes unidirectional, synchronous, and reversible motors — up to 1/20 hp. With and without reduction gearing — open or enclosed types. Expert engineering service available to help you get the exact motor for your application. Write today for free copy of new Catalog F-4271-6.

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Small Motors • Automatic Controls • Industrial Instruments • Aircraft Controls • Air Distribution Products
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ABSTRACTS

A New Structural Index

Abstracted from "The Application of a New Structural Index to Compare Titanium Alloys with Other Materials in Airframe Structures" by L. R. Jackson and S. Gordon, Titanium Metallurgical Laboratory, Battelle Memorial Institute, Columbus, Ohio. Paper No. 56-AV-10, presented at the ASME Aviation Division Conference, Los Angeles, Calif., March 14-16, 1956.

To evaluate structural materials for airframes, engineers make use of values known as "specific strength" and "specific yield," which are the ratio of the ultimate tensile strength to density and of the compressive yield strength to density, respectively, of a given material. In addition, structural indexes for plates and columns are used, the indexes being calculated from a formula which is found to be unreliable since it predicts only the stress at which any one member of a complex section will first buckle.

A new method of predicting the load under which a section in compression will fail was proposed in 1954 by R. A. Needham, and on it is based the development of a new structural index for the evaluation of the strength/density ratio of materials in compression.

The indexes obtained by the new formula have been compared with the results of actual compression tests performed on aluminum sections at room temperature and on titanium-alloy angles and channels at room and at elevated temperatures. Excellent agreement between the indexes and the test results were obtained in all cases.

On the basis of the results obtained, the authors have found that the new indexes "may not only be used to weld the behavior of components made from titanium alloys to the background of experience on conventional materials, but also to make the first steps toward the prediction of behavior that might be expected at high temperatures."

While the authors are interested especially in predicting the behavior of titanium and titanium alloy components, the formula and the indexes obtained from it are not restricted

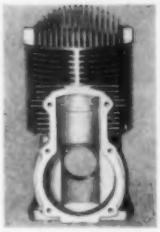
(Continued on page 349)

DIE CASTING REPORT

Streamlined—lightweight and rugged—thanks to advanced designing and use of die casting

4 cylinder sizes from one die!

Interchangeable cores in a master die enable Precision to produce 4 different sized aluminum cylinder blocks for West Bend.



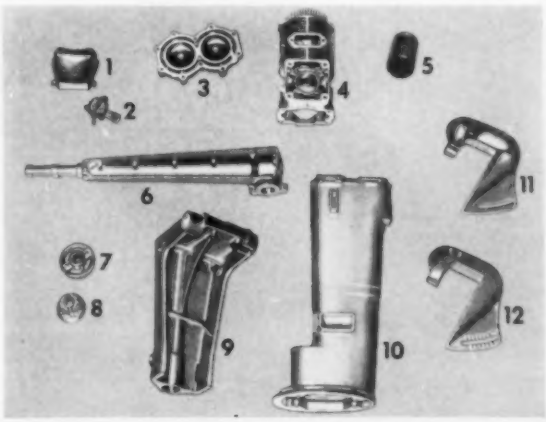
This year America's waters are being churned by a steadily growing outboard motor population. New companies entering this field have had to meet stiff competition from the "old line" producers. How have they done it?

The West Bend Aluminum Company, of West Bend, Wisconsin, is a good example. Their Hartford Division is currently putting on the market a line of high performance outboard motors ranging from 2 to 25 H.P. One of the most important factors in cutting down on excess bulk and weight has been the strategic use of aluminum die castings. Cooperative planning on die-cast design of components helped achieve compactness, streamlined appearance and light weight. All this without sacrificing strength where needed.

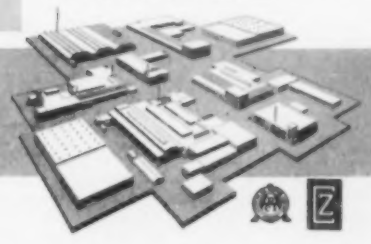
For production and assembly savings, it will pay *you* to investigate the use of die-castings. Let the Precision team of experienced die design engineers look at your problem. The result! Savings on machining, assembly and unit cost!

Typical Aluminum Outboard Motor Parts

1. Transfer port cover
2. Gas pump cover
3. Cylinder head
4. Cylinder block
5. Steel bushing insert
6. Steering handle
7. Bearing cage
8. Slip clutch plate adapter
9. Swivel bracket
10. Drive shaft casing
11. Stern bracket
12. Stern bracket



Write on your letterhead for free copy of "DIE CASTINGS . . . UNLIMITED" Precision Castings Co., 42 Warren St., Fayetteville, N. Y.



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A DIVISION OF **HARSCO Corporation**

FAYETTEVILLE, N. Y.—SYRACUSE, N. Y.—CORTLAND, N. Y.—NEW YORK, N. Y.
CHICAGO, ILL.—CLEVELAND, OHIO—KALAMAZOO, MICH.

THE LATEST NEWS ON POSTFORMED PHENOLITE®

Manufacturers slash assembly time, eliminate rejects, improve products with PHENOLITE parts postformed by NATIONAL

Production speeded, unit costs reduced—from plant after plant comes news of big profits and savings through the use of PHENOLITE parts postformed by National.

Reasons for their cost-cutting efficiency are: (1) National makes PHENOLITE in *many* grades with combinations of service properties unmatched in any other type of material, and (2) National's applications engineers and fabricators are experts at adapting PHENOLITE to specific requirements. We can help you all the way from development of a material—through design—to the delivery of fully fabricated parts.

Want to simplify design and speed production? It will pay you—in reduced unit costs or in product improvement at no added cost—to explore the advantages of special, ready-to-use PHENOLITE parts postformed by National. Send us the problem that's nagging you—and be sure to ask for our new 16-page Catalog on PHENOLITE and other National products. We'll send it promptly, without obligation. Simply write Dept. H-7

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PEERLESS INSULATION • KENNETT MATERIALS HANDLING RECEPTACLES • VUL-COT
WASTEBASKETS • LESTERSHIRE TEXTILE BOBBINS • VULCOT PRODUCTS FOR THE HOME

R. F. Bogart, one of National's staff of applications engineers, shown holding a postformed copper clad PHENOLITE printed circuit.

Reverse bends and small radii—toughest problems in forming—were involved in shaping this spring-action, snap-on cover for a switch voltage changer. National's postforming technicians used PHENOLITE C-534-F to achieve a 1/16" radius bend.

Corrugated, bent, and punched after forming, this insulator had to be made of extraordinary stock to withstand unusual stresses. National made use of a double die and PHENOLITE C-534-F to form the corrugated component without cracking or fracturing the piece.

Bending and drawing in one operation were difficulties faced in forming this bus bar joint cover. National ended the trouble by using PHENOLITE X-114-A. PHENOLITE can be formed or deep drawn easily—without damage to the material and without expensive dies.

DESIGNERS:

Visit us when you vacation in NEW ENGLAND

you may be able to enjoy this better living all year long.

New England vacations are always lots of fun. But they can't compare with year 'round living in this pleasant countryside.

This year make your visit a double-duty visit. Plan to spend at least one day at our East Hartford headquarters. It's possible that you and your family will be able to enjoy New England living advantages twelve months a year.

Our jet engines have won tremendous international acceptance. As a result, we have innumerable openings at many levels. These are career openings — not just jobs. They all offer unusual opportunities for professional growth and advancement.

To further increase your professional development, a nearby graduate center, established in conjunction with Rensselaer Polytechnic Institute, offers training toward advanced degrees. Employees are eligible for substantial tuition assistance.

It is impossible to itemize all our tangible and intangible advantages. To learn more, mail the coupon immediately. Your telephone number is important since we may want to call you to arrange a meeting with our supervisors.

PRATT & WHITNEY AIRCRAFT
DIVISION OF UNITED AIRCRAFT CORPORATION
EAST HARTFORD 8, CONNECTICUT

World's foremost designer and builder of aircraft engines

Mr. E. M. Peterson, Dept. 7, Design Employment
Pratt & Whitney Aircraft, East Hartford, Conn.

I would like to learn more about your openings for product and component designers. My experience has been in the following fields:

☐ Nuclear Design	☐ Aerodynamics	☐ Bearings
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The engineers at Ross Laboratories, Seattle (Wash.), specify Synchron Motors exclusively to power the ultrasensitive depth finding equipment the company designs and manufactures for use in commercial fishing boats and pleasure craft. The equipment, sold under the trade names Sportsman and Fisherman Depth Finders, is vital in navigating, anchoring, and fishing.

Synchron Timing Motors are precision engineered and thoroughly tested for durability, accuracy, and dependability. Each motor is made with standards as fine as .0001 tolerance and subjected to 51 individual inspections. The pinion and shaft are machined in one piece from solid steel. Oil-retaining double bearings are provided on the rotor shaft, the reduction train, and the output shaft.

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to this use, but can be made to predict the behavior of any new material, and will also be used to calculate the dimensions of plates and columns made of more familiar materials.

The criteria by which the authors evaluate the behavior of structural components are the ultimate tensile strength and the *crippling* (not buckling) strength of columns. The concept of crippling strength, or, perhaps better, of crippling load is new:

"When a stiffener or a stiffened panel is subjected to a compression load (but not affected by column length), buckling will start in a free edge. The exact load at which buckling starts is difficult both to define and to measure, and depends on the sensitivity of the measuring device. As load is increased, however, the initial buckle will pass through one of the corners in a stiffener.

As the testing on the stiffener proceeds, a point is finally reached at which the load it can carry reaches a maximum value and then begins to drop off as the stiffener collapses."

In the paper, the aluminum test data are the Needham's report, data on titanium alloys are from tests performed at Convair (San Diego) and at Boeing (Seattle).

Is the Yardstick for Estimating Individual Engineering and Scientific Potential Reliable?

Abstracted from "Is the Yardstick for Estimating Individual Engineering and Scientific Potential Reliable?" by Allen Schooley, Electronics Div., U. S. Naval Res. Lab., Washington, D. C.; presented at Western Electronics Show and Convention, San Francisco, Calif., August 24-26, 1955.

The selection of promising young engineers and physicists for infusion in a development or research organization appears to be one of the most important tasks confronting the engineer or research manager. It is the competence of these young employees that will have a major effect on the future success of the organization.

Through the years, much thought and study have been given to ways of making good selections from avail-

(Continued on page 350)

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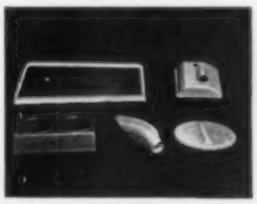

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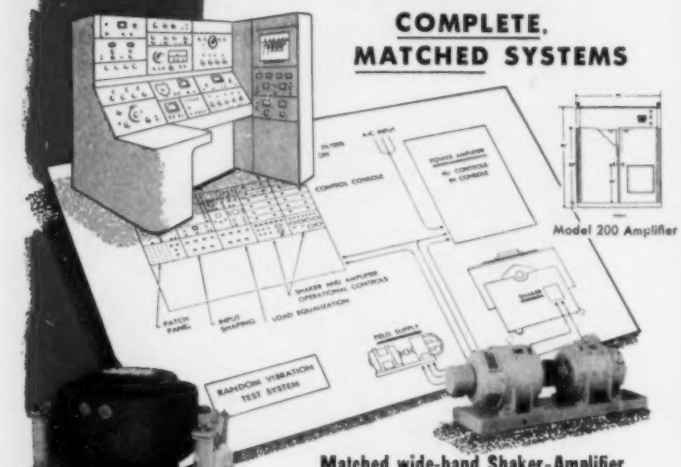

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able candidates. This experience has resulted in the general custom of considering the following major factors in making decisions on hiring:

1. Educational background including grades.
2. General interest and hobbies.
3. Opinions of references.
4. Opinion of person conducting interview.

Most managers feel that their judgment, based on such data, is quite good. However, it is usually possible to recall cases where the initial judgment has proved to be unusually good or unusually bad.

This paper is based on the case histories of twelve persons who were hired as B. S. degree graduates about twelve years ago to do electronic work at the Naval Research Laboratory. The potential value of the employees, based on information available at the time they were hired, was compared with their now established record.

Preferred Limits and Fits

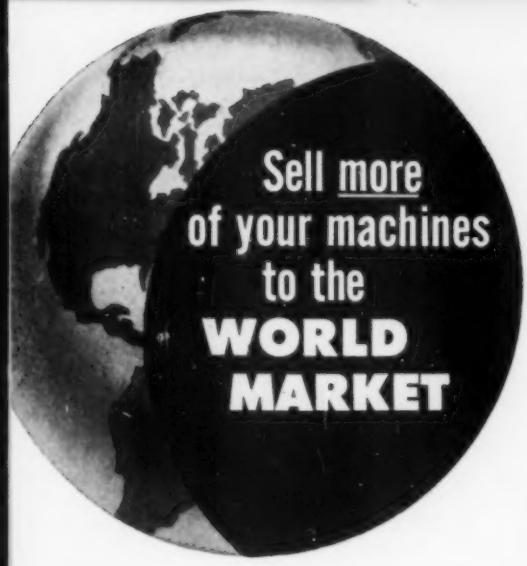
Abstracted from "Preferred Limits and Fits," by Prof. Z. R. Bliss, Executive Officer, Div. of Engineering, Brown University, Providence, R. I.; *The Magazine of Standards*, Part 1, May 1956.

A great deal of time, thought, and discussion has been devoted during the past 35 years to the problem of standards for gages, and tolerances and allowances for metal fits. Approval of American Standard B4.1-1955 is the latest step in a program begun in June 1920. It provides the first real successor to the American Standard B4a-1925, approved in 1925, which has remained in use up to the present time.

The new standard is the result of work by Sectional Committee B4 organized under the procedures of the American Standards Association in 1920 and sponsored by the ASME. The committee devoted considerable study to possible revision of American Standard B4a-1925, but no definite decisions had been made by March 1943. At that time the Automotive Council of War Production and the War Production Board requested ASA to organize a war committee to expedite the work and complete the revision.

An ASA war committee was formed

(Continued on page 352)



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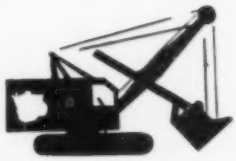

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That is why F. Perkins Ltd. believe they can help you sell more export machinery. Perkins not only make a complete line of high speed, light weight diesel engines—they have sales, service and parts outlets in 106 countries as well! (See list on this page)

Also, these versatile engines are available to specifications of your own engineering department. Deliveries can be made from Sterling sources to you or direct to your overseas branches or distributors.

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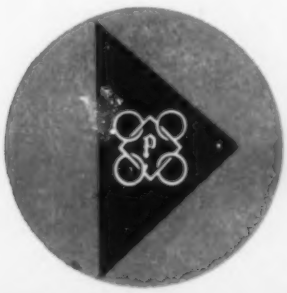

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under the chairmanship of John E. Lovely, then chief engineer and vice-president of Jones and Lamson Machine Co., Springfield, Vt. It immediately prepared a draft proposal which was submitted not only to American industry but also to the British Standards Institution and the Canadian Standards Association. This procedure brought to attention the possibility of a unified American-British-Canadian standard.

The British submitted a basic table of tolerances and allowances, classified into different grades, and proposed tables of recommended fits for general engineering purposes, each fit being completely specified by tolerances of the mating parts, and an allowance. This suggested pattern is now followed by the latest standards on limits and fits adopted by all three of the ABC countries.

Preferred Sizes

In February 1945, when it became obvious that the war was drawing to a close, the ASA war committee decided that further work on a war standard was not justified. Following the disbanding, a subcommittee of Committee B4 prepared a document, "Limits and Fits for Engineering and Manufacturing, (Part I)" which was issued as American Standard B4.1-1947. This publication contains definitions and a table of preferred basic sizes, but does not contain information on recommended fits. It was contemplated that a Part II would be issued but little work had been done on it before the reawakening of interest in ABC unification of limits and fits pushed it into the background. In 1953, the ABC system was finally adopted and the American delegation voted to recommend approval of the ABC proposals as the basis for an American Standard when and if such a standard might be developed. To determine whether the result was acceptable to and desired by American industry, a questionaire was distributed to members of Committee B4 and to other representative sections of American industry. Replies to the questionaire were decidedly favorable to the proposal.

The ABC system covers a range of diameters from 0.04 to 20 in.; the new American Standard extends this

(Continued on page 313)

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F-100 Super Sabre photo courtesy of North American Aviation, Inc.

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range to 200 in. It consists of a series of preferred basic sizes; a preferred series for tolerances and allowances; a system of 13 tolerance grades; and 5 tables of recommended fits, as well as explanatory material and definitions. The series of preferred basic sizes is substantially the same Table 1 of American Standard B4.1-1947 up to the 4-in. limit of the older table, but is extended to 21 in. in the new version. The new preferred series of tolerances and allowances extends the range of and adds certain values to Table 2 of B4.1-1947. The table of tolerance grades indicates the 13 fundamental grades of tolerances, giving the values of 21 size range steps from 0.04 to 200 in. The definitions have been revised to conform to the recommendations of the Joint Committee on Definitions of ASA sectional committees.

Tables of recommended fits constitute the most important part of the standard and will undoubtedly be of greatest interest to the designer. The tables gives a series of standard types and classes of fits on a unilateral hole basis. However, for those who wish to use bilateral holes or a basic shaft system, methods of adapting the basic tables are described.

Three Classes of Fits

Fits are designated by symbols and are divided into the three basic classes of Clearance (C), Transition (T), and Interference (N), and further subdivided for tabulation into Running or Sliding (RC), Location Clearance (LC), Transition (LT), Locational Interference (LN), and Force or Shrink (FN). In addition to its class, each has a grade designated by a number; for example, RC3 for a grade 3 running fit.

Since the new standard was finally accepted in October 1955 no significant information is yet available concerning its actual use to date. Section Committee B4 is naturally desirious of gathering all possible information concerning the practical operation of standard. It requests that anyone using the standard communicate his experiences to the author at the Div. of Engrg., Brown University, Providence 12, R. I.

Copies of Amer. Std. Preferred Limits and Fits for Cylindrical Parts, B4.1-1955 can be obtained from the Amer. Stds. Association at $1.25 each.

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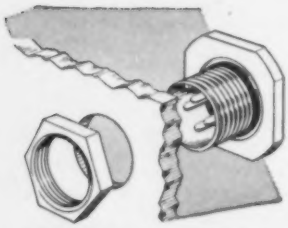

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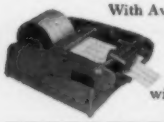

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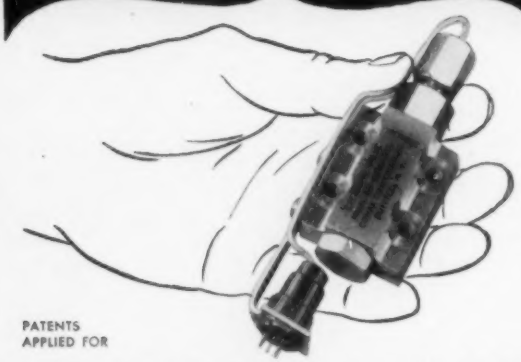

PATENTS APPLIED FOR

The CONAX EXPLOSIVE VALVE is a light-weight valve that operates instantaneously upon the firing of a small, completely contained explosive squib. The "Normally Closed" model provides dead-tight shut-off before firing and may be used for long term storage of gas or liquid under high pressure. Weighs only 5 ounces . . . releases in .002 seconds . . . proof pressure to 7500 psi . . . zero leakage at 5000 psi . . . smallest possible envelope size.

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EXPLOSIVE PRODUCTS DIVISION
CONAX CORPORATION
7811P SHERIDAN DRIVE, **BUFFALO 21, N. Y.**

NEW BOOKS

Machine Literature Searching

JAMES W. PERRY, ALLEN KENT, and MADELINE M. BERRY, 10½ x 8 *in.*, 162 *pp. Published by Interscience Publishers, Inc., 250 Fifth Ave., New York 1, N. Y.* $4.

"Developments in electronic equipment are making it possible to design the library of the future not as a warehouse of books and documents, but as a dynamic instrument that supplies knowledge required for evaluating problems, for planning investigations to extend available information and for making decisions."

Today a librarian finds it an impossible task to deal effectively with the mounting volume and complexity of scientific literature. Fortunately the emergence of giant electronic computers with vast memories and the ability to perform logical correlations offers a solution not only to the librarian's problem, but also to the researcher's need for a more discriminating indexing procedure.

However, to make best use of the opportunities offered by these computers much careful thought must be put into the design and analysis of indexing and coding systems and the construction of appropriate machine language. The fifteen essays included in this volume are of an exploratory nature into the determination of fundamental principles of bibliographic organization as it is related to machine design, indexing, terminology, code development, semantic units, definition and operational criteria.

Preferred Circuits

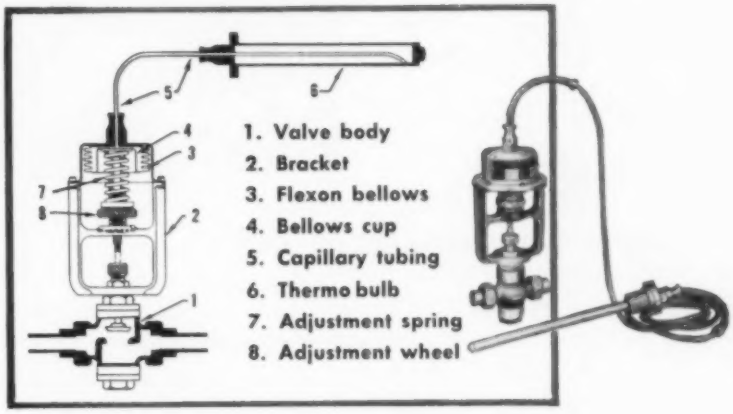
J. H. MUNCY. 8 x 10½ *in., approx. 200 pp. Available from Government Printing Office, Washington 25, D. C.* $1.75.

This looseleaf handbook is comprised of two parts, the Preferred Circuits Manual and Notes to the Preferred Circuits Manual. The

(Continued on page 358)

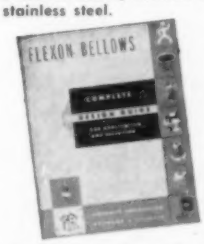
FLEXON® BELLOWS *Design Briefs*

Flexon Bellows Converts Vapor Pressure to Closing Force in Temperature Regulator



FLEXON® OFFERS THE COMPLETE BELLOWS SERVICE

Flexonics Corporation manufactures a complete range of bellows and bellows assemblies in brass, bronze or stainless steel.



The Flexon Bellows Design Guide gives valuable application and design information. Write for your copy, today.

Lawler thermostatic temperature regulators are self contained vapor-pressure-operated devices for automatically regulating the flow of liquid or steam through a valve. Manufactured by Lawler Automatic Controls Inc., Mount Vernon, New York, the type "S" illustrated is only one of the Lawler Line of thermostatic controls that rely on Flexon Bellows to translate vapor pressure into positive action of the valve disc, thereby regulating flow.

If your product must be temperature sensitive—or pressure sensitive—specify Flexon Bellows developed by cost-conscious Flexonics engineers who know how to combine performance with economy.

Let us examine an outline of your requirements—we may be able to show you the way to lower costs.

FLEXON® QUALITY
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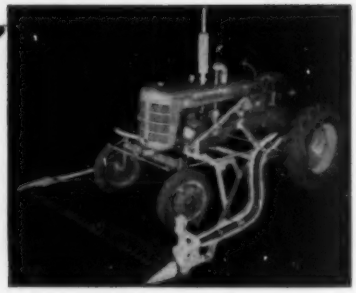
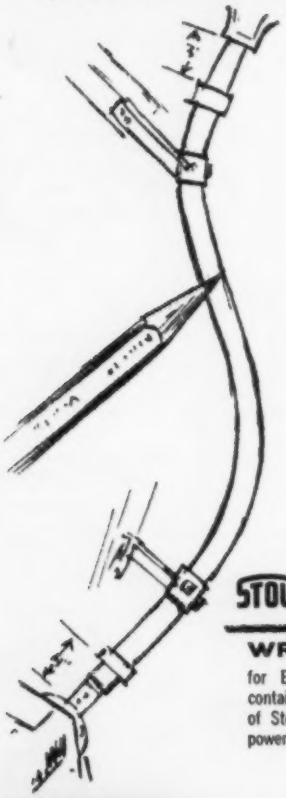
FLEXON BELLOWS DIVISION
1351 S. THIRD AVENUE, MAYWOOD, ILLINOIS
FORMERLY CHICAGO METAL HOSE CORPORATION

B-35

Manufacturers of flexible metal hose and conduit, expansion joints, metallic bellows and assemblies of these components.
In Canada: Flexonics Corporation of Canada, Ltd., Brampton, Ontario



picture of a
design engineer
who **had** a
power transmission problem



Know who this fellow is?

We'll tell you*, but first, here are the facts about the power transmission problem he licked with STOW flexible shafting.

Briefly, this company had the problem of supplying power to a mower on a farm tractor, from the tractor's power take-off which was 7 feet away. Raising and lowering the mower further complicated the problem because of the relative motion introduced between the ends of the shaft. Further, the drive used had to be dependable, economical, easy to maintain and safe.

*This Krengle's Inc. engineer found the answer in STOW flexible shafting. 1-inch shafting, with specially designed end terminals, was used for this job.

STOW your problems—
WRITE TODAY
for Engineering Bulletin 525 containing detailed information of Stow Flexible Shafting for power drives and remote control.

STOW
MANUFACTURING CO.
Originators of the Flexible Shaft
426 State St., Binghamton, N. Y.

manual explains use and design methods of 32 preferred circuits, including voltage regulators, multivibrators, blocking oscillators, video detectors, and amplifiers. Schematics of each circuit are provided, together with characteristics and other information permitting ready selection and construction. The preferred circuits were derived after experimental measurements on both commercial and military equipment. The Notes explain the steps which led to the selection and design of each preferred circuit, and is of value to either experienced or inexperienced designers whose interest extends beyond an immediate problem. Standardization of electronic circuits results in lower production costs, quicker shifting from development to production, lower parts inventories, simplification of mechanized production, conservation of engineering manpower, maintenance training, and greater reliability.

ASME Handbook Engineering Tables

Edited by Jessee Huckert, *Professor, Mechanical Engineering, The Ohio State University* 7 x 10 *in.*, 692 *pp. Published by McGraw-Hill Book Co., 330 W. 42nd St., New York 36, N. Y.* $12.

This handbook which includes many tables of design standards not generally found in reference books, is divided into 15 sections

1. Bar Stock and Shafting—Conversion Factors—Formulas for Stress and Strain—Properties of Sections and Cylinders
2. Bearings—Bearing Load Analysis
3. Spur Gears
4. Helical and Herringbone Gears
5. Bevel Gears
6. Worm Gears
7. Cylindrical Fits—Standard Tapers
8. Keys and Keyseating
9. Bolts — Counterbores — Screw Threads—Slots—Broached, Drilled, Reamed, and Tapped Holes
10. Serrations and Splines
11. Nuts — Pins — Snaprings — Washers—Wrench Openings
12. Springs
13. Aircraft and Mechanical Tub-

(Continued on page 359)

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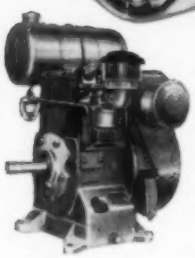

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14. Electric Motors — Graphical Symbols—Welding

15. Gaskets—Hydraulic Standards and Symbols—O-Rings—Packings—Seals

Each section consists entirely of tables of design data. Typical of these are the table of gear tooth proportions, AFBMA Bearing Standards, and spring load and deflection charts.

Electronics in Management

LOWELL H. HATTERY and GEORGE P. BUSH, *Editors*. 9¼ x 6¼ *in.*, 207 *pp. Available from The University Press of Washington, D. C., 1621 Connecticut Ave., N. W., Washington 9, D. C.* $6.

This book is adapted from the proceedings of the First Institute on Electronics in Management presented at The American University in November 1955. It reviews and analyzes management potential and problems arising from development and installation of automatic systems especially data processing systems. Among problem areas treated are: planning, procedures, organization, personnel, fiscal and executive.

The volume has been divided into four parts: Management Impact, Equipment, Case Examples, and Suggestions for Management. A selective annotated bibliography is included.

Surveys in Mechanics

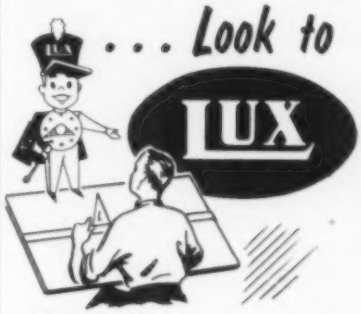
Edited by G. K. BATCHELOR, *Trinity College, Cambridge, and* R. M. DAVIES, *Dept. of Physics, University College of Wales, Aberystwyth.* 8¼ x 5½ *in., 475 pp. Published by the Cambridge University Press, American Branch, 32 East 57th St., New York 22, N. Y.* $9.50.

This volume has been published as a tribute to Sir Geoffrey I. Taylor on the occasion of his seventieth birthday. It includes a short biographical sketch of this remarkable man who has been awarded six honorary degrees, seven medals, and was knighted in 1944 in recognition of his substantial contributions to science.

Ten independent articles (actually

(Continued on page 361)

When Timing is the Problem . . . Look to



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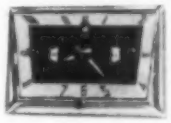
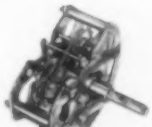


FULLY AUTOMATIC RANGE TIMER CONTROLS



TIMERS FOR ELECTRIC DRYERS

RECORDER CLOCK

APPLICATIONS

- PARKING METERS
- WASHERS & DRYERS
- BATTERY CHARGERS
- MILK COOLERS
- COFFEE MAKERS
- DISH WASHERS
- GAS RANGES
- SUN LAMPS
- ROTISSERIE COOKERS
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- RECORDING INSTRUMENTS
- AIR CONDITIONERS
- REFRIGERATION SYSTEMS
- ELECTRIC RANGES
- CLOTHES DRYERS

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Section showing crosscurved spring in housing

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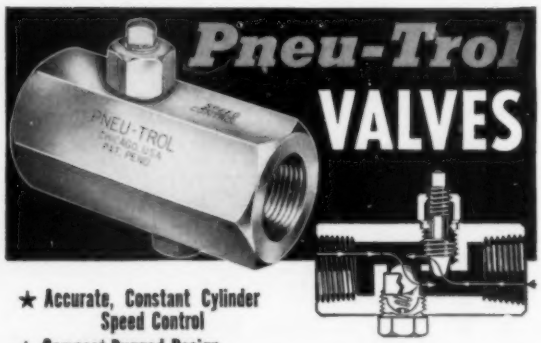
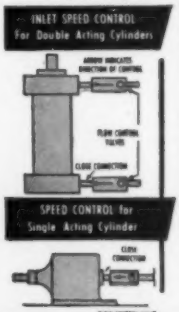


★ Accurate, Constant Cylinder Speed Control
★ Compact Rugged Design
★ Simple, Easy Speed Selection ★ For Air, Oil or Water Applications



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papers) make up the bulk of this book. Each article is a survey of the present position in some field of mechanics and is meant to be an authoritative account suitable for non-specialist readers. Each is followed by an extensive list of references for further study.

The subjects of discussion include: The Mechanics of Quasi-static Plastic Deformation in Metals, by R. Hill; Dislocations in Crystalline Solids, N. F. Mott; Stress Waves in Solids, R. M. Davies; Rotating Fluids, H. B. Squire; The Mechanics of Drops and Bubbles, W. R. Lane and H. L. Green; Wave Generation by Wind, F. Ursell; Viscosity Effects in Sound Waves of Finite Amplitude, M. J. Lighthill; Turbulent Diffusion, G. K. Batchelor and A. A. Towsend; Atmospheric Turbulence, T. H. Ellison; The Mechanics of Sailing Ships and Yachts, K. S. M. Davidson.

Inventors Handbook

FRED ROTH, 8½ x 11 *in.*, 10 *pp, paperbound. Available from author, Fred Roth, 15143 Hartsook St., Sherman Oaks, Calif.* $1.

A short, practical, step-by-step guide for the inventor in planning, patenting and marketing his invention. It lists 21 things to do before contacting a patent attorney and 22 things to do after the decision to patent is reached. Included is a list of locations in the United States at which copies of issued patents may be inspected.

Electronic Data Processing For Business and Industry

RICHARD G. CANNING. 6 x 9 *in.*, 322 *pp. Published by John Wiley & Sons, Inc., 440 Fourth Avenue, New York 16, N. Y.* $7.

The basic purpose of this book, says the author, is to advocate the efficient use of computers to meet management's problems. He looks at a company as an integrated operation acting to reach some goal set by management. In this operation, a continual flow of information is necessary.

Systems engineering looks at the information requirements of the whole operation and lays out a data

(Continued on page 363)

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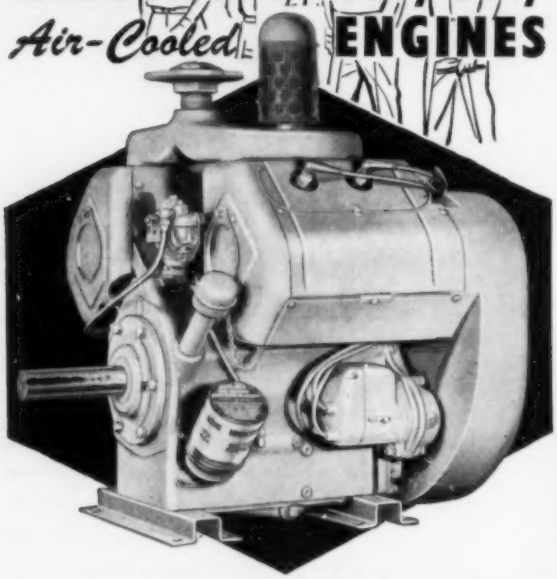

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Just a couple of more good reasons why it pays to specify Wisconsin Heavy-Duty Air-Cooled Engines for your equipment . . . service-proved, performance-proved and climate-proved wherever engine-powered equipment is used.

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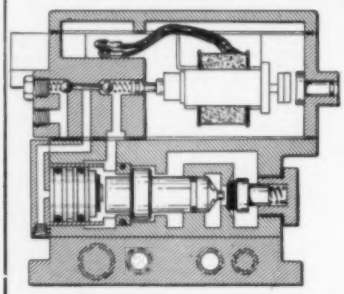

FEATURES

A—Manual Operating Button

B—Water-tight and Dust-tight Solenoid Enclosure with built-in Electrical Junction Box.

C—Cover chained to Body

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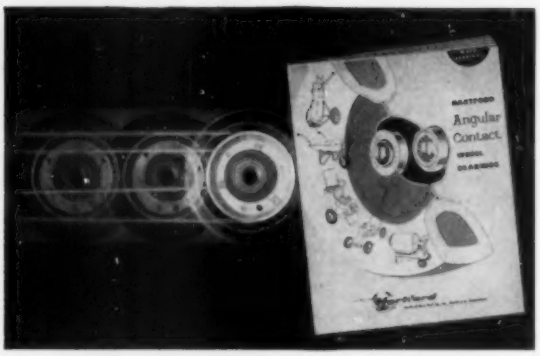

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New literature provides complete technical information on the various types of Hartford Wheel Bearings including selection, mounting, lubrication, plus comparative charts on combined radial and thrust capacities in pounds and dimensions. Hartford Wheel Bearings are extensively used by manufacturers of wheels for power mowers, wheelbarrows, golf carts, velocipedes, wheeled industrial equipment, large wheeled toys and belt idler pulleys. WRITE FOR YOUR FREE COPY TODAY.

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The Hartford Steel Ball Co., Inc., 3 Jefferson Ave., W. Hartford 6, Conn

processing system to meet those requirements. Accordingly, the author attempts to take these machines out of the "black box" category and give management the information necessary to decide what types of equipment are best suited for a given application. The book does not give comparative data for specific machines but concentrates on such important basic characteristics as command structure.

The scope of the book is wide: it is aimed at that period of time that begins with management's interest in electronic data processing and ends with a proposed plan of action. The principles of this new field are discussed to show how they should be considered during the planning phase.

Machine Design

J. E. Shigley. 6 x 9 *in.*, 523 *pp. Published by the McGraw-Hill Publishing Co., Inc., 330 West 42nd St., New York 36, N. Y.* $7.75.

To design is to make decisions. The study of machine design is an investigation of the various decisions which determine the mechanical arrangement of parts in a machine and which influence the size, shape, or material of a finished machine part.

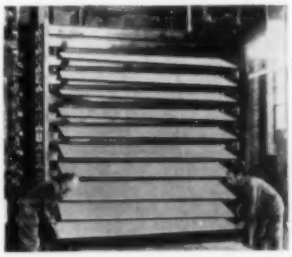
For many years courses in machine design have been severely criticized for stifling the ingenuity of the student. It is the author's experience that all students of engineering possess it to a remarkable degree, that it can be developed by exercise, and that unless it is developed it may be dormant for a very long time.

Throughout the entire book, which is written as a text for students of engineering, emphasis is placed upon setting up of the problem and evaluation of the solution. The mere substitution of numbers into formulas to obtain answers has little educational value. In general, the solution of design problems first requires the reader to choose a method of attack; many of the problems are set up with sufficient background information so that several choices are available. Secondly, he must select the data and information required for the solution. These data may be concealed in an excess of information, or in other cases the

(Continued on page 365)

VERSATILITY
in Resins...

● BONDING...OR COATING



Wood particles are bonded into durable board and molded products with Durez resins.

In electronics, resins in dip compounds form tough, dust-proof, heat-resistant coatings.

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Braking generates heat, but the resin bond in linings prevents "fading", adds wear.

In refrigerator insulation, a protective bond of resin safeguards batts from moisture.

● RESILIENT...OR HARD

Resins are used widely in rubber stocks and adhesives to add reinforcement and wearing qualities.

...and for exceptionally high shock resistance, molding materials are bonded with Durez resin.

...do these suggest benefits for your business?

These examples suggest only a few of the many ways in which business is profiting from the characteristics of Durez phenolic resins. Their qualities of insulation, toughness, and resistance to extremes of temperature and humidity, and to attack by many acids and mild alkalies hold wide promise for investigation into profitable new uses. If your product or processes call for impregnants, bonds, coatings, or reinforcing agents, we may be able to help you. Our experience as leaders in the development and production of phenolics is at your service.

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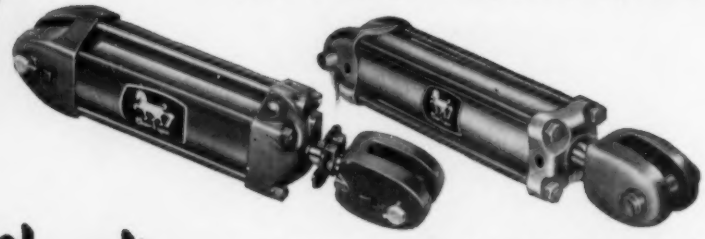

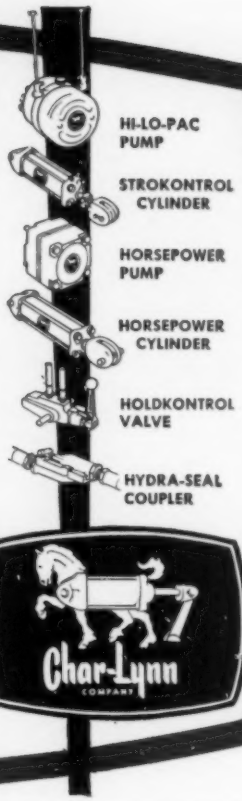

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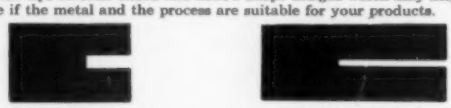
Light metals design tips

Tips on designing semi-closed and hollow extrusions in magnesium

Because magnesium is easily extruded, it is ideal for a number of product applications where many other metals would not be suitable. Here are some tips on semi-closed and hollow shape designs which may help you decide if the metal and the process are suitable for your products.

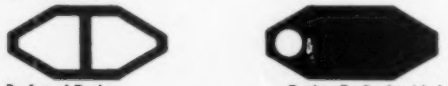


Preferred Design — Design To Be Avoided

Semi-closed shapes requiring long, thin die tongues should be avoided. For best extrudability the length of the tongue should not exceed three times its width although it is possible to extrude lengths five times the width.

Preferred Design — Design To Be Avoided

Shapes requiring unbalanced die tongues to not constitute good extrusion design.



Preferred Design — Design To Be Avoided

Hollow shapes with unsymmetrical voids, or with voids having inadequate section thickness between them are undesirable.

As we buy and use magnesium extrusions extensively in our own products and in parts and products we fabricate for others, we can give you authoritative, unbiased answers to specific questions you may have on this subject. Although we do not have extrusion design literature for distribution, we do have a useful Design Handbook covering other design factors. Copies on request.

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problem may require the use of outside sources in order to obtain it. Thirdly, the reader must make his own set of simplifying assumptions, after which he may solve the problem. The last step is an evaluation of the solution in the light of the information which is given. Various means are used and emphasized throughout the text to make this step possible.

Subjects covered in the text are: stresses, materials, design principles, fasteners, springs, bearings, gears, clutches, brakes, couplings, belt and chain drives; shafts, and the design of miscellaneous machine members such as cylinders, plates, flywheels and hydraulic machines.

Effective Communication On the Job

6 x 9 in., 294 pp. Published by American Management Association, 1515 Broadway, Times Square, New York 36, N. Y. Members—$4.50, nonmembers—$5.50.

Management is slowly recognizing the fact that communication is the largest part of its job. Most supervisors are sure that they have little to learn in this field but still experience difficulties because of several problems. "First, we mistake the form of communication for its substance. We pay too much attention to media and devices, too little to content or purpose. Second, some of us oversimplify. Third, management tends to talk too much and listen too little."

Most supervisors and executives, regardless of mutual endowment, can improve themselves as communicators. This book has been designed to aid in this process. Among the skills covered are sensitivity to both the language and emotional content of messages; awareness of communication barriers and techniques for overcoming them; and the ability to tap the ideas and experiences of others by sympathetic and attentive listening.

Also discussed are specific communication situations, such as giving orders; disciplining; employment interviewing; performance appraisals; handling problem interviews; constructively communicating with superiors; participating effectively in meetings and conferences.

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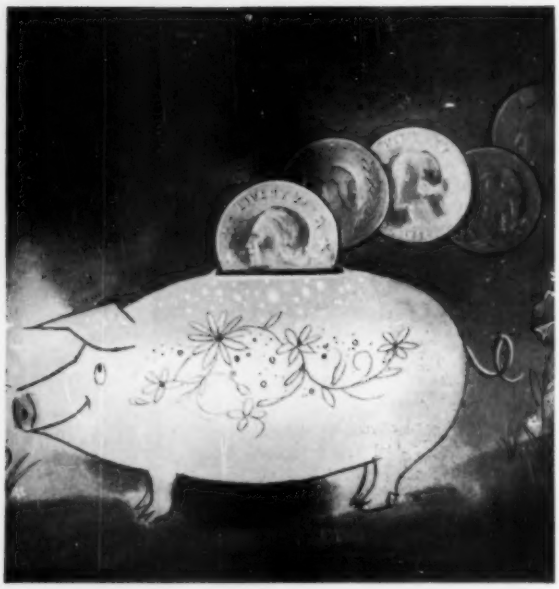

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Comments on Many Things

To the Editor:

Now, as before, I read your editorials and Sans Souci with great attention and honestly I can say they are of great value, both for employer and employee. I would like to make some comments not only on your editorials but also on articles by other writers.

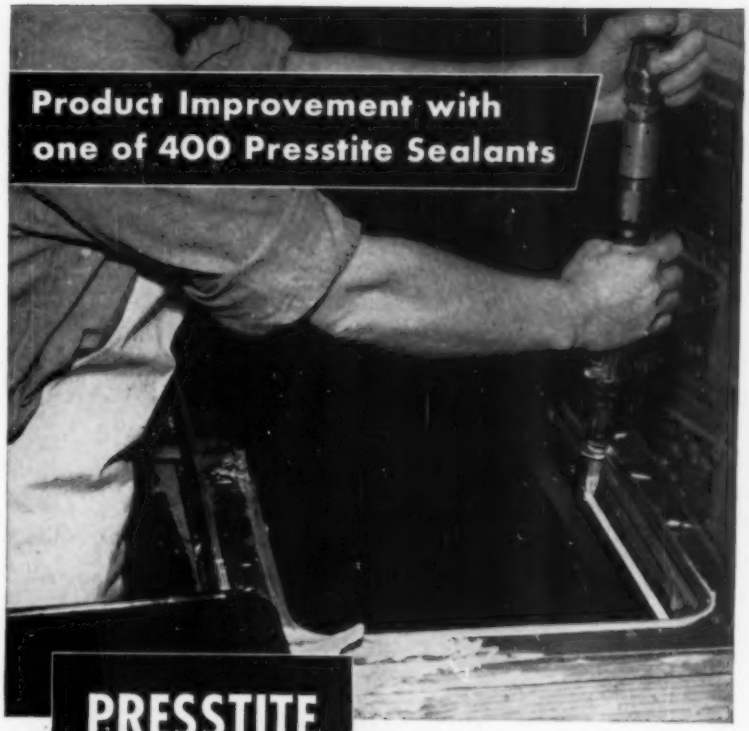
First the letter of Gerd Runken, published in your March issue. Firstly, I thank you for the estimate of German engineers and my old country, Germany, in your January edition. I should say Hunken's letter is very inopportune and does not tell the facts. Having been a technical adviser and coordinator for scientific research under Admiral W. Canaris and the German Navy, I know something about what really was going on under the Nazi reign.

I can say, you are so right, absolutely right, about all you did say in your article on education. I know from my own experience that it was more important to teach Nazi doctrine and to be a good Nazi than to teach engineering like in the old days. Thank heaven it is over now, and I do hope for ever.

During World War I, we German engineers began already to realize, that we could learn a lot from yours and other countries. It was your standardizing which inspired us to organize the so-called "DIN". At this time we could not even take, say, ½ in. screw out of one engine and fit it to another make. Every maker had his own system. So you see, every country makes a contribution and we should never underestimate the knowledge of others. This must be left to dictators and their followers.

Referring now to your editorial of January and February, I shall say, every designer who will follow your advice, will achieve success. A de-

(Continued on page 369)



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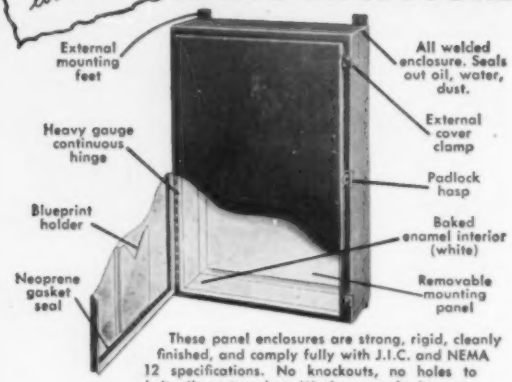

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signer has to be sure he has all necessary information before proceeding with a new design. When I read your March editorial, it seemed to me that your seeds are already sprouting. I am sure that soon the need for help in education will be forthcoming. This way, industry will help itself to progress.

When I used to tell my fellow students that I was going to be a designer they would deride me and say in a tone of pity "am Banche sollst du liegen and Striche zieh dien Leben lang", which means, "On the stomach, you shall lay down and draw lines all of your life." Well, they could not realize what it means to be a designer, to create, to develop and to research. But already, in 1921, German industries began to realize the value of college-educated designers with scientific backgrounds. Big companies employed professors as their chief designers. Soon, the designer became paramount in industry.

Today, for development and research, the designer often needs to be a physicist, too, and that is why good designers are so rare. But beside this scientific education some apprenticeship in industry is needed also, from the tooling and testing bench, to the executive desk. That will give the ideal designer. —Dr. Josef Starziczny
Rio de Janeiro, Brazil

Ed—Your comments are doubly welcome. First, because of your perceptive approach to our editorial material and, second, because of your experienced and creative approach to the field of design.

Competition from Europe

To the Editor:

This Sunday afternoon I read your article in the 1956 "Pulsebeat of Industry." I was especially interested as I spent three months early last spring in Europe, calling on business firms in relation to our electronic industrial balancer.

I, too, was tremendously impressed with the progress being made in Germany, the new buildings, modern machinery, last-minute designs in production lines—especially the Mercedes, Opel and Volkswagon plants. The Germans have the ability to man-

(Continued on page 371)

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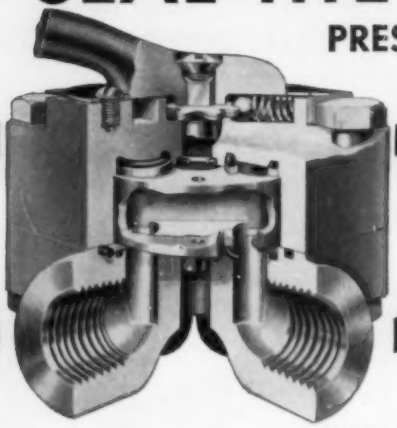

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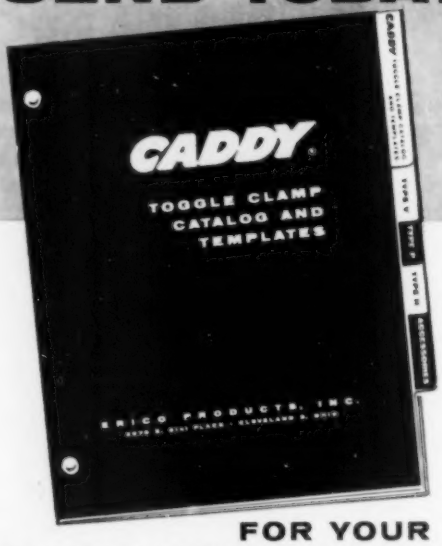

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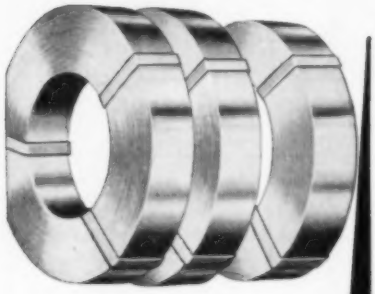

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age and organize, but I will have to confess that I think that the French engineers are the most brilliant (and my mother was German). Our subject, vibration balancing machines, is quite mathematical by nature. I had an opportunity to observe the different nationalities in the many conferences I held.

Today, I believe, America is going to have to face this competition from Germany, France and England, where the wage rates are around 50 to 60¢ an hour, compared with our $2.00. It is not going to take many years.

—Marcellus Merrill
Denver, Colo.

Ed—Your letter is an accurate statement of an oncoming problem. You, and all other readers, are invited to send in your ideas on possible solutions, for publication in these columns.

Right Tester, Wrong Company

To the Editor:

We appreciate the fine write-up on page 350, May issue of *Product Engineering*, accorded our new Model 106 high voltage tester.

However, we noticed that in this case one of those things has occurred that turns editors' hair gray and credits the new product to another manufacturer.

We fully understand how these things can and do happen.

—Elmer Slaughter
Slaughter Co.

Ed—We thank you for your understanding. We are making certain that all inquiries are forwarded to you.

Printed Wiring

As machines become more automatic electrical controls require a substantial increase in the number of wires. Printed wiring offers many advantages for industrial equipment provided certain limitations are recognized. A special staff report to appear in the August issue will cover types of printed wiring, materials and components, and recommended design procedure.

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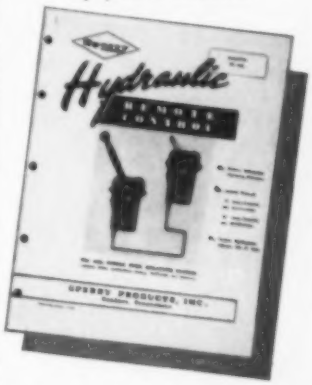
for hydraulic, mechanical and electrical applications



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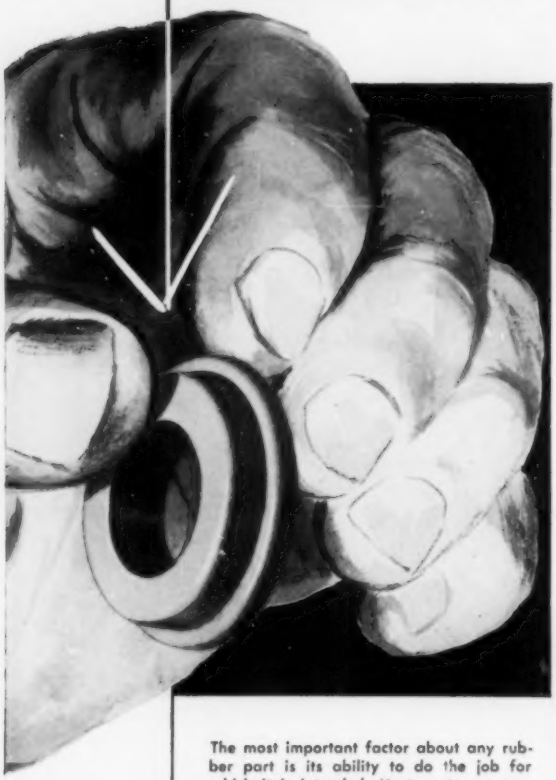

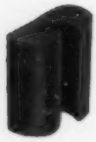

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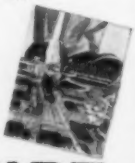

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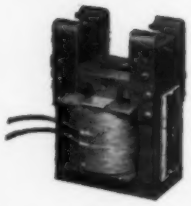

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PRESS PREVIEWS

Power Driven Hoe Uses Zinc Die Castings

A new power driven hoe, the Electro-Hoe, is now being marketed by the W. R. Brown Co. of Chicago. Designed to be used by the home gardener, the new tool utilizes 14 specially designed zinc die castings for efficient performance, durability, and corrosion resistance.

Answering the need for a gardening tool that requires minimum effort for both application and maintenance, the Electro-Hoe uses a ¼ inch drill unit including motor as its power source. By using the drill handle together with an interchangeable left or right hand hoe handle, the gardener can obtain hoe action without the tiring bent-over posture required by conventional hoes.

The drive shaft, which runs in two oilless bearings, drives a zinc die cast universal joint which in turn operates a 7:1 worm gear. The worm gear has bronze bearings which locate as well as hold the gears. Operating speed is 300 rpm.

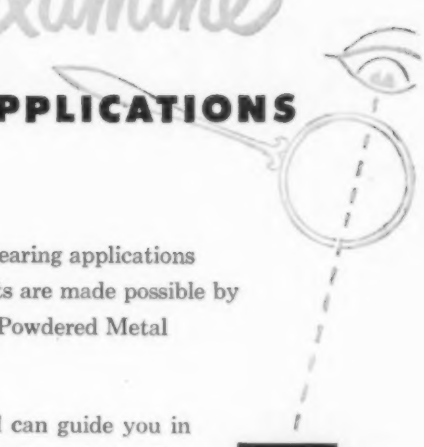
The use of zinc die-cast parts provides corrosion-resistant properties at an optimum weight for the application. If made of aluminum and machined, the total weight of these parts would be only 1 oz. less than that required for die casting with zinc. This slight saving in weight is offset by superior mechanical properties, corrosion resistance, casting characteristics and overall cost of the zinc die castings.

The die-cast parts consist of a two-part gear head, 2 oil seals, 2 hexagonal drivers with attachment keys, 4 blade spacers, 2 outer washers, a saddle bracket and a drive shaft coupling. The drive shaft tube is welded steel tubing, zinc plated; the hoe blades are zinc-plated spring steel. The 14 die-cast zinc parts are cast simultaneously on one gate. After casting, the 14 components are trimmed in a single operation with one trim die. This effects a significant money and labor-saving factor in the overall manu-

(Continued on page 375)

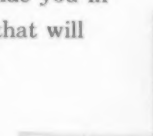
time to re-examine

BEARING APPLICATIONS



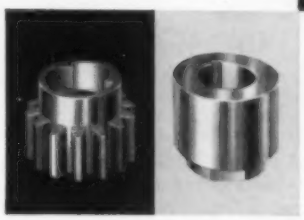
Striking cost reductions in bearing applications in many mechanical products are made possible by the use of Bunting Sintered Powdered Metal Bearings and parts.

Bunting engineering counsel can guide you in the selection of designs and alloys that will provide bearings of exactly the type, design and material that will fully meet both cost and functional requirements, whether the material be Cast Bronze or Sintered Metal.



A competent group of Bunting Sales Engineers in the field and a soundly established Product Engineering Department put at your command comprehensive data and facts based on wide experience in the designing and use of cast bronze and Sintered Powdered Metal Bearings and parts.

Write to our Product Engineering Department in Toledo or consult our nearest Sales Engineer.



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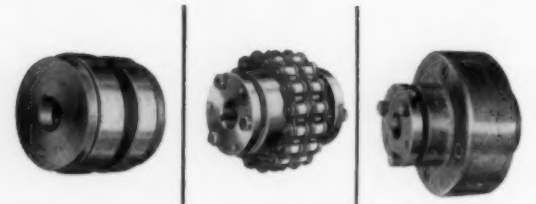

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facturing run, incorporating an economical production rate, a minimum of secondary operations and no material waste. The only machining steps required are the drilling of four holes in the gear head castings and one hole in the saddle bracket for the drive shaft tube.

Design problems involved in casting the 14 zinc parts required careful consideration of cores and drafts that would need machining or troublesome pulls. Emphasis was directed toward parts that were simple to cast and which required a minimum of machining. By adjusting core sizes to compensate for shrinkage, the designer was able to compensate for and hold dimensions to within .001 and dispense with drilling. The only secondary operation needed was a single ream to remove necessary draft, and the tapping of the threaded holes.

Zinc was chosen for its casting ease, machineability, dimensional stability and inherent capacity to withstand the hard usage generally encountered in abrasive soils. The manufacturer's experience indicates that the zinc parts require no protective coating for normal use other than a mild passivating before painting.

L & N Plant Opening Commemorates Franklin's 250th Birthday

Leeds and Northrup Company has opened a new instrument plant in North Wales, Pa. which will be devoted entirely to manufacture of Speedomax Recorders and Recorder Controllers, Metermax Combustion Controls, L & N Load-Frequency Controls, and certain other automatic instrumentation widely used by science and industry. Manufacturing operations employ standard machine tools, engravers, winding machines and molding machines, and such operations as heat-treating, spraying and lacquering, connecting, calibrating, testing, assembling and tool and die making.

Because of the wide variety of products, mass-production techniques are seldom used, but great emphasis is placed on proper sequence and arrangement of operations, efficient tooling and other measures to assure

(Continued on page 377)

Cambridge

WOVEN WIRE CONVEYOR BELTS
take the bottlenecks out of
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OPEN MESH of rustproof, all-metal belt provides free circulation of process solutions and drying air; assures waste-free packaging.

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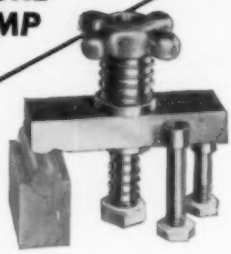

2. SELF POSITIONING horizontal, vertical or upside down—strap will not fall out of position even in unclamped position.

3. WIDER APPLICATION—SWINGLOCK can be operated in restricted areas where there is not enough room for forward and backward strap movement.

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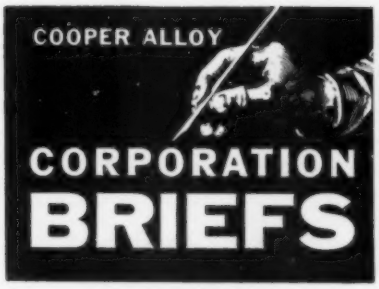

● Edited by GEORGE BLACK

DOUBLE-D REFINER

The Jones Double-D Refiner is said to bring an entirely new concept to the preparation of stock for the paper machine. Key to the design lies in the twin refining area with its double discs. For a more complete story ask for the February issue of Cooper Alloy NEWSCAST.

WHAT'S IN A TRADEMARK

Behind the Cooper Alloy trademark, cast or stamped into our stainless steel fittings, stands more than a quarter century of experience and the most complete production facilities in the industry. When you specify Cooper Alloy fittings you can be sure that every step from design to shipment is under the supervision of specialists. Look for the CA trademark before you buy . . . it is a sign of quality, experience and reliability.

DESIGN FEATURES FEATURED

Design features that have made the Cooper Alloy stainless steel valve the preferred valve for chemical processing are presented in the current issue of NEWSCAST. Diagrams and text combine to make a thorough presentation. Additional copies available on request.

NEW PUMP IN DEMAND

The new line of stainless steel rotary pumps announced by our Vanton Pump Division has taken the field by storm because it is the one (and only) pump of its kind without stuffing boxes or shaft seals. Bulletin VP561 gives the facts. Write for it today.

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economy of production and maintenance of quality. Inspection operations are performed in the flow of production wherever possible.

The manufacturing and office areas are a single-story building with partial mezzanine, providing over 6 acres of floor space and set in a 129-acre tract. There will be about 1300 employees at North Wales, including not only some of the firm's manufacturing people but also some from the departments of engineering, industrial engineering, personnel, accounting and maintenance. The L & N headquarters, and all manufacturing of laboratory instruments, furnaces and certain other products will remain at the long-established L & N location in Philadelphia.

A highlight of the opening ceremonies was a demonstration of combined 18th and 20th century electrical instruments. This was arranged in cooperation with the Franklin Institute, as a tribute to Benjamin Franklin whose 250th birthday is being recognized this year by organizations throughout the world.

Color TV Monitors Operations at Hanford

General Electric scientists are now using specially-designed color television to help them perform work in radioactive areas at the Hanford plutonium plant. The plant is operated by General Electric for the Atomic Energy Commission.

Crane operators who formerly observed their work in one of the "hottest" Hanford areas by means of a periscope now have a color closed circuit TV system, supplied by General Electric's Broadcast Equipment Section at Syracuse, N. Y. High image brillance on the TV screens and added depth perception afford easier operation of giant crane hooks.

Two cameras mounted in the radiation area of the building where plutonium is extracted from fissioned uranium are used to give operators a clear, wide-angle view of chemical equipment. The cameras, attached to the crane bridge, are connected by wire with two receivers in the cab. Two 7-inch screens on receivers give the same view as 10-inch screens be-

(Continued on page 379)

it's that simple!

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WHERE	WHY	HOW
Thread rolling machines	Holding position (leakproof)	Lapped sealing surfaces seal tight indefinitely as a result of wear compensation
Pressure testing in automotive production	Oil gets contaminated by scale in castings (not critical to dirt) reduced maintenance	Sealing surfaces in constant, intimate contact, dirt can't lock valving members – saves coil burn-out
Hydraulic work feed apparatus	(Leakproof) . . . as versus spool valves which cause overdemand on hydraulic system	Positive shut off of internal port to port leakage and of course, no external leakage
Machine tool chucking & clamping	Maintaining safe holding pressure (leakproof)	Saving auxiliary equipment such as pilot operated check valves
Automatic door openers	Quick action (high flow capacity)	No spools or poppets obstructing full, round flow passages
Solenoid controlled hydraulic system on machine you build	Better performance Lower manufacturing costs Reduce service problems	Shear-Seal valves have full flow, are leakproof, not sensitive to dirt Low priced, less auxiliary equipment and labor cost. Valves don't stick, saving coil burn-out; stay leakproof indefinitely, seals are wear compensating

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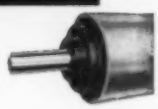
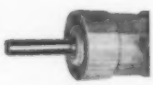
3 inch diameter and 3 feet long usual minimum.



Rubber covered squeeze rolls



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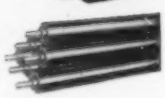
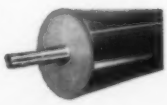
Stainless steel rolls

Teflon and other plastic rolls



Tube rolls, any metal



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cause of magnifying systems. Complete remote control of the cameras is obtained from the crane cab. This control includes all electronic adjustments, pan and tilt. The crane cab is windowless and has thick steel walls. It is located behind a thick concrete parapet to protect operators from radiation emanating from the chemical separations zone 80 feet below the crane.

According to G-E broadcast engineers, color TV was chosen primarily because the remote manipulation problem involves color coded objects and also because it gives added depth perception and better object resolution. The TV system uses the rotating color wheel principle, it was explained, because of the resulting economy, color rendition, definition, and low maintenance cost. Such a color system also has the advantage of simplicity of equipment.

Ford Organizes Missile R & D Subsidiary

Ernest R. Breech, chairman of the board, Ford Motor Company, recently announced the formation of a subsidiary company which will span a broad field of advanced scientific and technological operations ranging from guided missile systems to possible exploration of outer space. The subsidiary will be called Aeronutronic Systems, Inc., and will have its headquarters in California. Nucleus of the new company will be a group of scientists and engineers who formerly were organized under the name of Systems Research Corporation, a Los Angeles firm engaged in research and development in the design of weapons systems.

Mr. Breech said he felt the new company "can make an important contribution not only to the defense of our country, but the development for peacetime uses of the miracles of science in the fields of electronics, physics and nucleonics." Ford already has several plants devoted to defense work and still will be free to take on other military commitments independent of the subsidiary's program.

A seven-member board of directors includes Mr. Ford, Mr. Breech, Mr. Gerald J. Lynch, director of Ford

(Continued on page 381)

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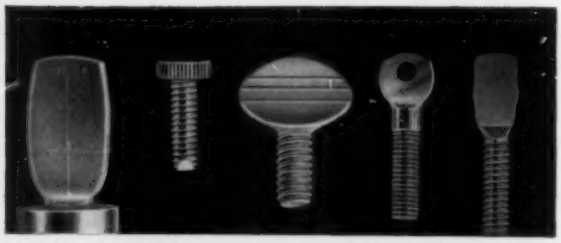

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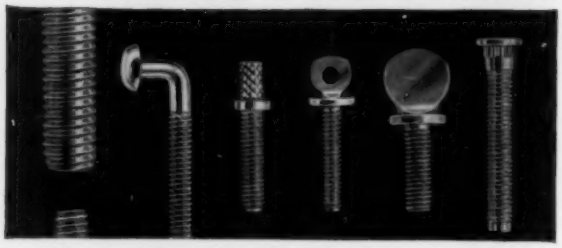
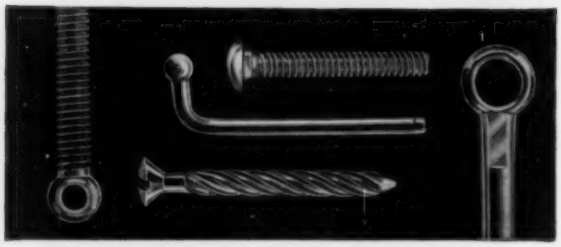


FOR PARTS LIKE THESE—AND



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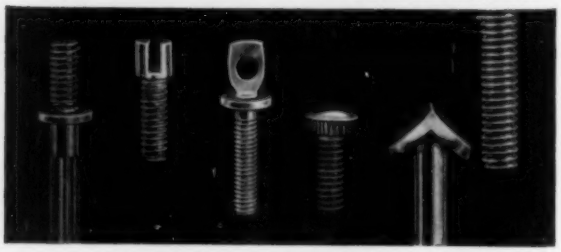
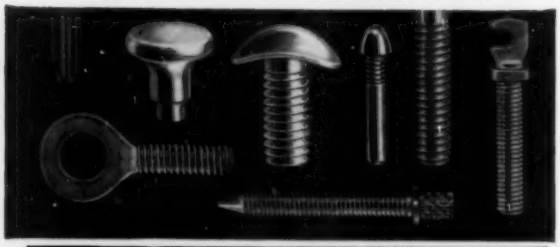


FOR COLD FORMING . . .



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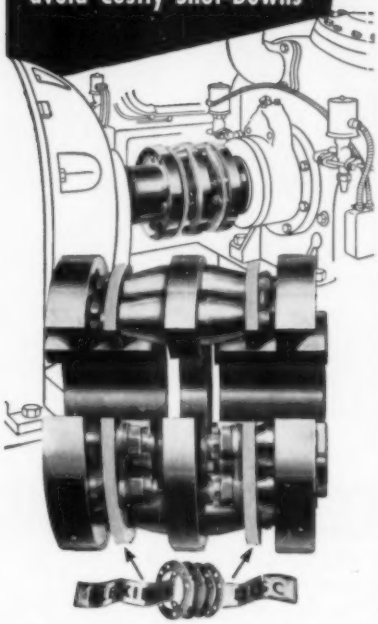

Patented Flexible Disc Rings of special steel transmit the power and provide for parallel and angular misalignment as well as free end float.

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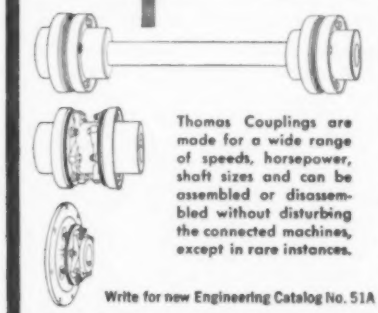
PERMANENT TORSIONAL CHARACTERISTICS	Drives Like a Solid Coupling. Elastic Constant Does Not Change. Original Balance is Maintained.



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THOMAS FLEXIBLE COUPLING CO.
WARREN, PENNSYLVANIA, U.S.A.

Motor Company's office of defense products and governmental relations; Dr. Ernst H. Krause and Dr. Montgomery H. Johnson of the SRC group; and Andrew Kucher, director of the Ford Scientific Laboratory. A chairman and a seventh member will be announced later.

Mr. Lynch, who is resigning his present position with Ford to become president of the subsidiary, said: "We expect to take a missile or other project and see it through from its very conception to its manufacture, and possibly even to its utilization and maintenance. When the new corporation gets to the point where it is ready to start production, it either will build new plants or use some of the modern, highly versatile facilities which Ford Motor Company has located strategically in all parts of the country."

Canadian Titanium Pigment Plant Started

Construction of Canada's first titanium pigment plant, at Varennes, Quebec, about fifteen miles northeast of Montreal, was begun recently by Canadian Titanium Pigments Limited, a subsidiary of National Lead Company. The plant, located on a 76-acre tract in an industrial area bounded by the St. Lawrence River on the north and by a main highway and railroad on the south, will be built at a cost of $15 million. The entire output of titanium pigment will go to Canadian industry.

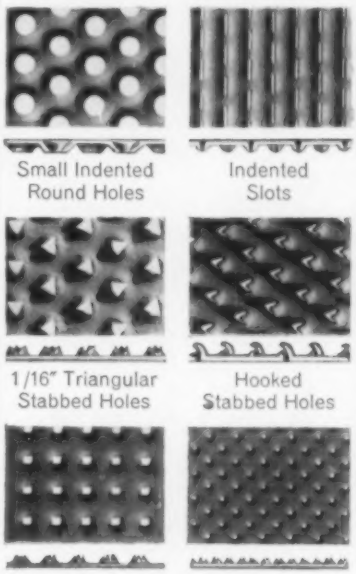
Approximately 750 workers will be employed at the peak of construction, which will be reached in the fall of this year. Production is expected to begin next year, and the plant will give permanent employment to about 300 people.

Since titanium pigments were first introduced into Canada by Canadian Titanium Pigments Limited in 1937, the demand for them has increased steadily each year. Titanium pigments are used by the paint, paper, rubber, plastics and other industries to add whitness, brightness and opacity to their products.

The Varennes site was selected by Canadian Titanium Pigments Limited because of its proximity to ti-

(Continued on page 383)

H&K
SURFACED PERFORATIONS
are used in many products



Illustrated are only a few of the many surfaced perforations for which we have dies. We have thousands of different die patterns to perforate practically any metal in sheets, rolls and coils.

If your product requires surfaced perforated materials, contact either H & K office or one of our agents. We will be glad to work with you on your perforating requirements.

Fill in and mail coupon to office and warehouse nearest you.

FIND NEAREST H&K AGENT in the Yellow Pages

Listed Under "Perforated Metals"

THE Harrington & King PERFORATING CO.

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Chicago 44, Ill.

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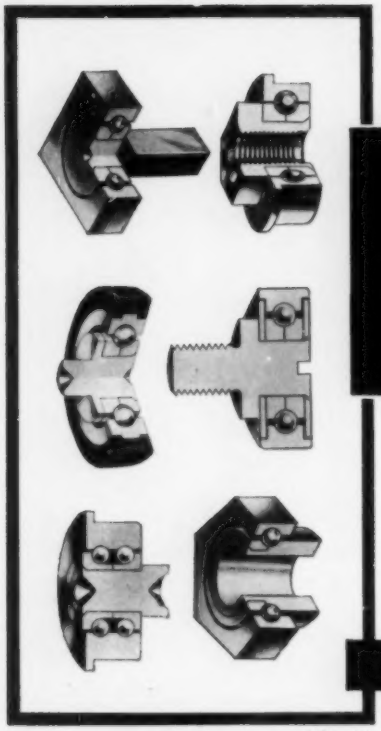
104 Liberty Street
New York 6, N. Y.

Please send me—

- ☐ GENERAL CATALOG NO. 52
- ☐ STOCK LIST of Perforated Steel Sheets
- ☐ SAMPLES of Perforated Plastics and Paper
- ☐ PRICE INFORMATION (NOTE: Send specifications of perforated materials wanted. If necessary send drawings or sketches.)

NAME_____
TITLE_____
COMPANY_____
STREET_____
CITY_____ ZONE_____ STATE_____



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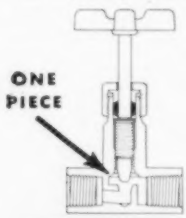
. . . for finer regulation of water, oil or gas

First needle valve to combine all the characteristics called for in modern industry. Embodies sturdiest basic construction—machined from solid bar stock—suitable for pressures to 10,000 psi and equally efficient in lower range. Note stem guide fused to body by new "Conoweld" process, eliminating faults of conventional two-piece valves. Stem 416 stainless steel. Stem threads fine pitch for strength and micrometer regulation. Body electro-zinc plated. Sizes ⅛" to 1", globe and angle patterns.



Ask for new Needle Valve Catalog

MARSH INSTRUMENT CO. *Sales Affiliate of Jas. P. Marsh Corp.* **Dpt. 39, Skokie, Ill**
Marsh Instrument & Valve Co. (Canada) Ltd., 8407 103rd Street, Edmonton, Alberta, Canada

tanium ore, to railroad and highway facilities, and to ample power and water supplies. Ore will be supplied in the form of slag from the electric furnaces of Quebec Iron and Titanium Company in Sorel, Quebec, approximately 40 miles downriver from the plant site.

The plant construction will involve the installation of highly specialized chemical processing equipment to extract titanium from its ore through stages from a black liquid solution to a white precipitated pulp, or hydrate, and then to a dry, extremely white powder. The buildings will enclose approximately 90,000 square feet and will reach up to eight stories above the ground.

In breaking ground for the new unit, Joseph A. Martino, president of National Lead Company and of Canadian Titanium Pigments Limited, said: "The expenditure of approximately $15 million for construction, the establishment of about 300 new jobs, and the continuous procurement of raw materials and supplies for operations will add considerably to the economic and industrial strength of Canada and the Province of Quebec. Our decision to make the capital commitment required demonstrates the faith and confidence of our company in the future of Canada."

High Speed Corrugator Featured in New Container Plant

The Wabash Fibre Box Company recently opened its new Chicago factory. One hundred thousand (100,000) square feet of the plant will be used to manufacture corrugated containers and will increase total corrugated box production by 480,000,000 square feet a year. At full capacity, the plant will employ more than 150 workers using the latest in corrugated box manufacturing equipment. Wabash Fibre Box Company was founded in 1924 at Terre Haute, Indiana, by Ward S. Hubbard with 30 employees, four machines and 20,000 square feet of space. In 1945, Wabash was affiliated with The Weston Paper and Manufacturing Co., Dayton, Ohio,

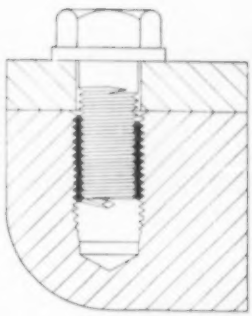
(Continued on page 385)

STRONGER CLEANER LIFETIME THREADS

in lighter, softer, thinner materials

with *HELI-COIL Screw Thread Inserts**

Heli-Coil Inserts, coils of stainless steel or phosphor bronze wire, produce superior internal threads that solve many design problems. Thousands of manufacturers are using them to greatly increase thread strength in light metals, wood, plastics. In ferrous metals they are widely used to stop corrosion, seizing, and galling. They increase thread life. In thousands of applications ***Heli-Coil*** Inserts now enable designers to use thinner materials, shorter thread engagements, lighter materials—to save space, time and money.



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☐ Please have a *Heli-Coil* Thread Engineer call.

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They're absolutely vibration-proof and cost you less... all ways!

If vibration is creating fastening problems on your equipment you need Camloc ¼-turn fasteners . . . because the unique design of these fasteners makes them absolutely vibration proof! Camloc ¼-turn fasteners not only hold fast but open fast . . . close fast. And you save with Camloc, too, because they are so easy to install, saving precious time and labor, and fewer fasteners are required for any given job.

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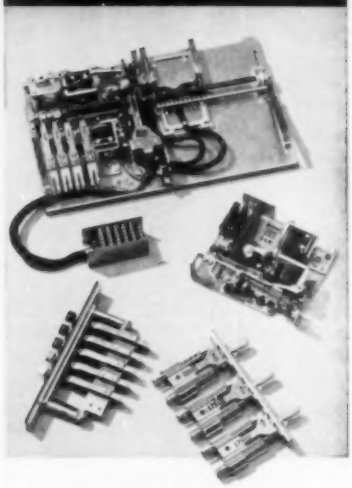

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now makes available to you the top-rated products formerly distributed only to the Independent telephone industry.

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START *with a look at our new catalog—sent on request. Or, if you have an immediate and specific problem, write to the address below and we'll suggest a solution.*

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with paper mills at Terre Haute, Indiana, and St. Marys, Ohio.

New equipment in the plant includes an 85-inch width Langston Corrugator. Three hunderd twenty (320) feet long, the machine produces corrugated board at the rate of approximately 125,000 square feet per hour. The machine has a two-way loud speaker system for inter-communication by the operating crew. The electric drive units are located in a separate room adjacent to the corrugator.

The plant has the latest type of corrugated box manufacturing equipment, including four two-color printer-slotters, one rotary slotter, one eccentric slotter, one partition slotter, one slitter, one automatic folder-taper capable of handling up to 5,000 units per hour, two hand tapers, several stitchers and the usual complement of smaller machines.

Before corrugated board can be processed beyond the corrugator, excess moisture must be removed. Recognizing also, the importance of humidity control of the plant atmosphere, Wabash has developed a means of utilizing moisture removed from the board to control operating area humidity as needed. A modern box testing laboratory is maintained by the company to assure top performance of its boxes. The machine shop is equipped to handle all ordinary running repairs and maintenance.

In addition to the 100,000 square feet of plant utilized for manufacturing, 30,000 square feet will be used for office space, designing department, lunch room, machine shop and locker rooms. A month's supply of roll stock can be handled in the storage area.

New Factory Operates Within Electronic Shield

The major problem in electronic welding of plastics is signal interference through the air and over power lines that upsets all types of communication equipment including radio and TV sets. The usual practice is to build a copper screen or shield around welding machines. Taking materials in and out of such cages entails heavy production costs.

R. L. Kuss & Co., Inc. of Findlay,

(Continued on page 387)

FILTER FORUM

Question:

What facts should a product designer determine before choosing a filter?

Success of any pre-planned filter installation is dependent on calculations which are fundamental to the special field of filter design. As a rule, the data is simple to determine. Where unusual conditions exist, Purolator will design special filters to handle them.

Answer:

These five facts: 1. Degree of filtration, 2. Flow rate, 3. Contamination to be removed, 4. Viscosity of fluid, 5. Provision for cleaning or replacement.

1. Degree of filtration of a filter medium means the size of the smallest particles filtered out with 98% efficiency—expressed in microns for sizes less than .001 inch.

2. Flow rate is the flow that a clean filter unit will handle calculated in terms of the fluid's viscosity and the allowable pressure drop through the filter.

3. Contaminants are any elements from water to dust that shouldn't be there—the materials themselves, their quantity, their size.

4. As a rule, the pressure drop through a filter for a given flow rate is proportional to its viscosity.

5. Provision for cleaning or replacement depends on the predicted effects of a temporary lack of filtration while the cleaning or replacement is accomplished. Can the equipment operate temporarily without filtration, for example, can it be shut down periodically – or will two filters be needed; one for cleaning, one for service.

MAIL COUPON FOR DESIGN INFORMATION

PUROLATOR

FIRST in the field of filtering

Dept. D11-729, Purolator Products, Inc., 970 New Brunswick Ave., Rahway, N. J.

Please send me the following filter information:

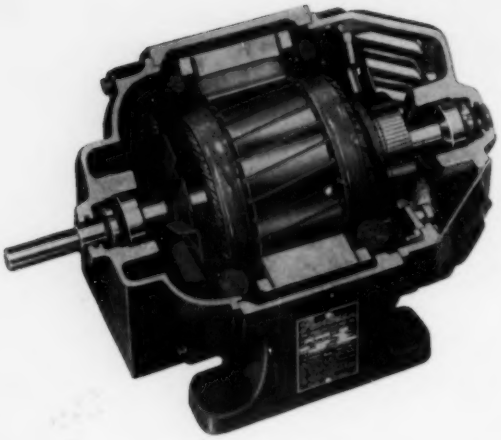
_____ Purolator's new "Filtration Manual for Designers". I'm enclosing 25¢ to cover postage and handling.

_____ Enclosed is a description of our filter problem. How should we solve it?

NAME _____ TITLE _____

COMPANY _____ ADDRESS _____

CITY _____ ZONE _____ STATE _____



SMOOTH TRANSITION in REPULSION-INDUCTION MOTORS

Speed-torque characteristics remain smooth from stand still to full speed on this Peerless Type BH Repulsion-Induction motor. Designed without a centrifugal switching or short-circuiting mechanism, it affords even transition from repulsion to induction characteristics. When operating on low voltage, Type BH runs at proportionately lower speed with satisfactory results. It's the ideal single phase motor for air compressors, floor sanders, hoists, and many general purpose applications where low voltage conditions prevail. Oversize commutator provides excellent commutation and long brush life. Over 15 years' successful field service from BH motors is your guarantee of top performance. Models from 1-5 HP are rated at 1750 RPM; 3/4-3 rated at 1150 RPM.

Teamwork of Peerless and OEM engineers has solved hundreds of special motor problems. Custom mountings, windings and minor modifications are developed to suit any application. Submit your motor requirements to Peerless. We'll help you select the one motor that operates your product best.

Write for Bulletin SDA-150 for details on REPULSION-INDUCTION MOTORS

ELECTRIC MOTOR DIVISION
THE *Peerless-Electric* COMPANY
FANS • BLOWERS • ELECTRIC MOTORS • ELECTRONIC EQUIPMENT
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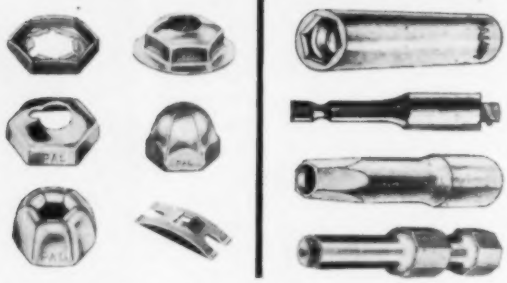
High-speed Assembly Method!

PALNUT LOCK NUTS **PLUS** **PALNUT SOCKET WRENCHES**



RESULT: Vibration-proof assemblies, with big savings in assembly time and cost

Specially-designed PALNUT magnetized socket wrenches and shanks for all standard power and manual tools, permit picking up, starting and tightening in one high speed operation. No fumbling with hand starting. Fast, uniform tightening.

WRITE FOR CATALOG and folder showing PALNUT assembly methods

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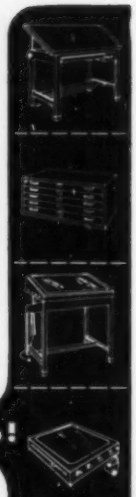
PALNUT TRADEMARK **LOCK NUTS**

PLANMASTER SECTIONAL STEEL FILING CABINETS of heavy gauge steel welded to form. For blueprints, maps, art, etc.



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Ohio has constructed a building 80 x 210 feet entirely of Armco steel. The exterior metal panels are soldered at the base to a copper mesh band which extends entirely around the building to a depth of four feet. All supporting columns are grounded and electric conduits, windows, doors, etc. are shielded. Two-inch fiberglas batt insulation and transite interior walls make the building easy to heat and cool in summer.

R. L. Kuss & Co., Inc. specialize in the engineering and development of fabricated plastic items to order. The company's facilities currently are producing many products not heretofore feasible because of high cost production or because no facilities existed for such production. Examples are electronic welding of an organisol coated fabric back, an unsupported vinyl bag front and a rigid vinyl filler neck into a single unit, and the development of means for sealing woven Saran to solid Saran parts.

The company has also developed two special non-toxic plastic films which provide high tensile strength with other special characteristics. One film will contain all fats and oils without leakage. The other film is made for all non-fat materials including chemicals. Both films are now used as liners for drums and containers. Tensile strength is sufficient to survive drop tests which crush the fiberboard containers but do not rupture the liner.

Lear Establishes European Subsidiaries

Lear, Inc., has established two operating companies abroad in support of its expanded European operation, it was announced recently by Richard M. Mock, president. A Swiss subsidiary, Lear, S.A., has been established at Geneva, where offices, laboratories and shops have been set up at Cointrin Aeroport. A German subsidiary, Lear Electronic, GmbH, has been set up at Reim near Munich. The company is a leading producer of advanced electromechanical and electronic instrument products comprising flight control, navigation and communication systems for airplanes and missiles.

Lear's founder and board chairman,

(Continued on page 389)

Our facilities are open...

to your inquiries about Cannon-Muskegon

VACUUM-MELTED

UltraMet alloys and service

WHATEVER your metallurgical problem, Cannon-Muskegon is equipped and staffed to solve it. Our metallurgists can make the *right vacuum-melted* alloy to fit your need. We can develop and test it in the ultimate in modern research and testing laboratories . . . then produce it to specifications in our modern plant. What's more, Cannon-Muskegon recommends proper handling methods for best results in your application.

In addition, Cannon-Muskegon offers a wide range of ferrous-, nickel- and cobalt-base alloys for your specific needs. These super-clean alloys are poured at pressures from 1 to 10 microns — available in sample or production quantities . . . in cast billets or ingots. Vacuum-melted alloys offer cleaner, smoother surfaces . . . greater tensile strength, ductility and wear life . . . higher electrical and magnetic properties. For complete vacuum-melting service, see Cannon-Muskegon.

Now available are:

- ***Materials for remelt*** — under conventional air melting, inert gas, vacuum.
- ***Casting development*** — includes research and experimental facilities for investment, shell mold, dry sand and permanent mold castings.
- ***Ingots or cast billets*** — for rolling, forging or extruding in individual weights up to 250 pounds.

ULTRA MET
VACUUM-MELTED ALLOYS
FOR INDUSTRY

MODERN RESEARCH facilities and experts are at your service. Constant research with known alloys develops our abilities . . . to your advantage. We are now testing alloys containing boron, aluminum and titanium . . . with interesting results. Send us your problems.

For full particulars write for our New Bulletin on Vacuum-Melting and Air-Melting facilities and products.

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2877 Lincoln Street Muskegon, Michigan

METALLURGICAL SPECIALISTS

CASE HISTORY **1**

REQUIRED:

A dependable supply of this small, machined electrode to meet customer's quality and quantity needs at reduced cost.

HASSALL SOLUTION:

Hassall-designed re-heading process, involving no critical dimension changes, resulted in a 59% cost reduction to customer.

CASE HISTORY **106**

REQUIRED:

Replacement for stud with insufficient head to act as stop for automatic hammering.

HASSALL SOLUTION:

Substitution of Hassall cold-headed collar stud with annular threads for greater holding power. Substantial cost savings.

CASE HISTORY **64**

REQUIRED:

An economical method of manufacturing perforating punches out of hard materials such as drill rod.

HASSALL SOLUTION:

The Hassall cold-heading process plus engineering skill overcame the difficulties presented by these alloys at considerable savings.

CASE HISTORY **37**

REQUIRED:

Bumper bolt with bonded rubber cap for license plate support.

HASSALL SOLUTION:

The large head on this bolt would ordinarily call for screw machining but the two lugs under the head ruled this out. Progressive cold-heading was Hassall's answer.

SPECIALTY MANUFACTURER OFFERS SAVINGS ON SMALL PARTS AND FASTENERS

Multiply these case histories a thousandfold and you'll get some idea of the variety of tough problems we crack, and the savings we effect for our customers in the course of a year.

Our cold-heading process—supplemented by secondary operations—imposes amazingly few limitations on the parts and fasteners we can make. Don't forget that we are not limited to "stock" sizes. These illustrations show that Hassall—a specialty supplier — can show you substantial savings, better deliveries and technical assistance on your small parts and fasteners.

Proof? Send us your specifications or write for catalog.

John Hassall, Inc., P. O. Box 2233 Westbury, Long Island, New York.

HASSALL

SINCE 1850

NAILS, RIVETS, SCREWS AND OTHER COLD-HEADED FASTENERS AND SPECIALTIES

A REAL SPACE SAVER!

the new, highly efficient...

ADVANCE TQ

MINIATURE RELAY

Only .94 cu. inches in size—yet it carries 3-amp. loads in the 4PDT combination. It's available up to 6PDT, and with class "H" insulation.

It's extra efficient, too, having only one air gap in the magnetic assembly. By spring-holding the armature rigidly in place, and using cross-bar contacts, all alignment problems are eliminated. Insulation is inorganic, hence there is no gassing or bubbling.

The ADVANCE TQ telephone type operates on 90 milliwatts or less. Withstands 10G vibration (10 to 55 CPS). Ambient temperature range: −55°C to +125°C. Life expectancy: 1,000,000 cycles with cross-bar contacts. Open and hermetically sealed types. Write for details.

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Quenches
Fuel-Thirsty Planes
for
FLIGHT REFUELING, INC.

Fibermold casts of high-impact plastic, the funnel-shaped Drogue that is of focal importance in mid-air refueling . . . for Flight Refueling, Inc. The Drogue, at the end of a length of hose trailing from the tanker, stabilizes the flight of the hose, and its 30-inch diameter provides a sizable target for the Probe on the fuel-thirsty receiving plane. Fibermold is proud to make this contribution to the extension of flight range and payload.

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Manufacturers of
High-Grade Reinforced Plastics

HB

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AND ALUMINUM CO.
Established 1903
262 Liberty St.•Springfield, Mass.

Producers of Non-Ferrous Sand, Permanent Mold & Die Castings

William P. Lear, moved his residence to Geneva last September to expedite the company's European expansion program. Mr. Lear is evaluating technical resources abroad for augmenting his company's increased engineering effort. He is also studying product designs and manufacturing techniques applicable to Lear's U. S. plants, as well as concluding arrangements for implementing import-export and licensing programs.

A substantial number of USAF and NATO planes based abroad are Lear-equipped. Three new French jets carry Lear instruments and equipment: the Caravelle transport; the Morane-Saulnier 760 executive plane; and the Mystere IV B manufactured by Marcel Dassault. Contracts for other applications of Lear equipment to foreign aircraft are now pending.

Bureau of Standards Chief Metallurgist Retires

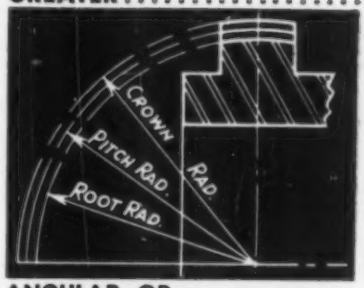
Dr. John G. Thompson, Chief of the Metallurgy Division of the National Bureau of Standards, has retired after more than 35 years of government service.

Born in Eau Claire, Wisconsin, in 1894, Dr. Thompson attended Cornell University, receiving his Bachelor of Chemistry degree in 1915 and his Doctor of Philosophy in 1921. His association with the National Bureau of Standards began in 1921 when he became a member of the Chemistry Division. From 1924 to 1929 he was employed as a chemist and metallurgist at the Fixed Nitrogen Laboratory of the Department of Agriculture on problems in connection with the synthesis of ammonia. He returned to the National Bureau of Standards in 1929 as a Research Associate for the Cerro de Pasco Copper Corporation, New York, and the following year was appointed Chief of the Chemical Metallurgy Section. He was appointed Assistant Chief of the Metallurgy Division in 1942 and Chief in 1946.

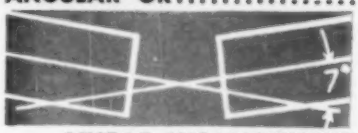
Dr. Thompson has made outstanding contributions in fields of research pertaining to the preparation of pure metals, the evaluation of their properties, gases in metals, special refractories, corrosion, and powder metal-

(Continued on page 391)

PERFECT SPHERICAL TOOTH FORMATION PERMITS GREATER.....



ANGULAR OR.....

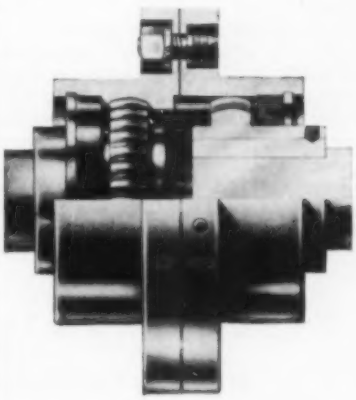


.....LINEAR MISALIGNMENT

The Philadelphia SPHEREFLEX COUPLING features a Spherical cut tooth which allows a ball and socket action between mating teeth up to 14° angular misalignment—and due to this angular capacity, a much greater amount of parallel misalignment is possible, which varies directly as the pitch diameter of the gears. All this is accomplished by gearing having a minimum back-lash.

By using Sphereflex Couplings, you can eliminate excessive bearing loads and cyclical bending stresses, which are caused by misalignment between shafts.

Send for Catalog C-560, and be convinced.



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These *new* ROCKFORD Clutches and Clutch Plates have been developed by ROCKFORD Clutch Engineers to take full advantage of recently discovered facing material. Actual field tests on heavy duty equipment have resulted in adoption of MORLIFE clutches by builders of tractors, earth movers, graders, shovels, cranes, trucks, oil field equipment and power units. For information how these *new* Rockford MORLIFE Clutches will improve the operation and increase on-the-job hours of heavy duty machines, write Department E.

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lurgy, and is the author of more than 35 technical publications.

He was successful in extending the slip-casting process to the preparation of thin-wall crucibles of alumina, beryllia and other special refractories that lacked the property of plasticity. Slip-cast beryllia crucibles were used in preparing the "super-pure" ingots of iron. The results of his work served as the basis for the production of slip-cast crucibles of special refractories by other laboratories for use in the preparation of exceptionally pure metals.

Dr. Thompson was the leader of an international cooperative study that established the accuracy of the vacuum-fusion method for determining oxygen in the plain carbon steels, either as aluminum-killed, silicon-killed, or rimmed. The vacuum-fusion method is now extensively used, not only as a tool for research but commercially, as the "standard" for determining the oxygen content of steels and other metals.

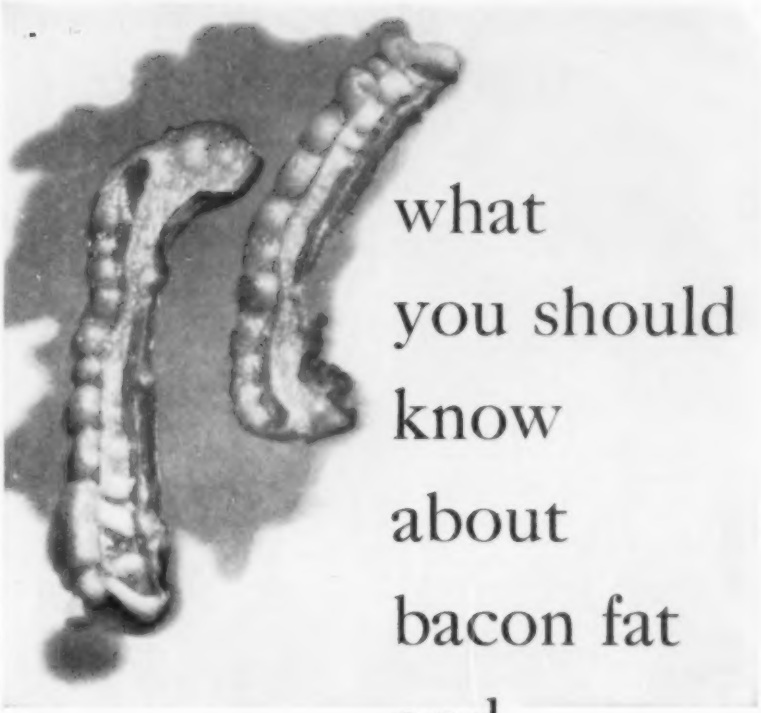
During the period of World War II, he conducted researches on beryllium-aluminum alloys under the auspices of the War Metallurgy Committee; this work received an award from the Office of Scientific Research and Development. His study of the metallurgy of beryllium and uranium for the Manhattan Project was also recognized by an award from the War Department.

Since World War II he has been honored by service as a Presidential Appointment Member of Annual Assay Commission for 1950. Member of the Materials Advisory Board of the National Research Council; Member of Advisory Committee on Revision of New York State Industrial Code No. 21; Chairman, Washington Chapter, American Society for Metals; and Conferee, First World Metallurgical Congress, 1951. In addition, Dr. Thompson has served on many technical committees of various engineering societies.

Automatic Switch Company Plans New Plant in N. J.

Excavation has been started for the erection of a large, new plant at Florham Park, N. J., for the Automatic

(Continued on page 393)



what you should know about bacon fat and Albanene®

Here's the buying information you should have to get the *best* value when you buy tracing paper.

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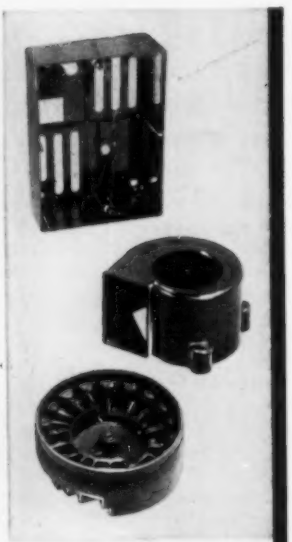

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Switch Company, designers and manufacturers of solenoid valves and electromagnetic controls. The new facilities will have double the capacity of the ASCO plant now located in Orange, N. J.

According to president W. F. Hurlburt, ASCO expects to move its entire operations to the new location by the end of 1956. The modern, one-story building, having 120,000 square feet of floor area, will occupy a 30-acre site in the suburban area approximately 15 miles west of Newark, and about 10 miles from the present factory. ASCO electromagnetic controls include automatic transfer switches, remote control switches, contactors, relays, solenoids, electric plant controls and complete control panels. An engineering department is maintained for special solenoid valve or electromagnetic control requirements.

Westinghouse to Expand Transformer Facilities

The Westinghouse Electric Corporation transformer division has announced a $500,000 expansion of its specialty department at Reynolds Development, near Sharon, Pa. The expansion program, one of the first in Westinghouse since the end of the long strike, is designed to expand the production of control, general purpose, dry-type distribution, electronic, aircraft, and pulse transformers.

Automatic Electric Breaks Ground for New Plant

Automatic Electric Company today began a multi-million dollar expansion program that will give it one of America's most modern industrial facilities. The expansion got under way when six business executives maneuvered huge earthmovers over sections of the 167 acre site of the company's new 1,300,000 square foot headquarters plant to signal start of the new construction project. Activities presently housed in fifteen separate buildings on Chicago's near west side will be transferred to the new site late in 1957. Operations now scattered

(Continued on page 395)

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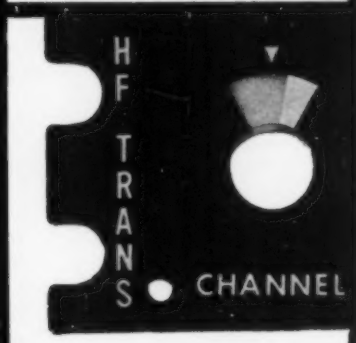

The Lackon® engineering staff of the United States Radium Corporation will readily assist your panel engineering department during the initial design stage. The cooperative application of their skill and experience in lighting techniques to your panel design will speedily resolve design difficulties, result in decided production economies, and yield a remarkably superior finished product. For information write Dept. PE-7

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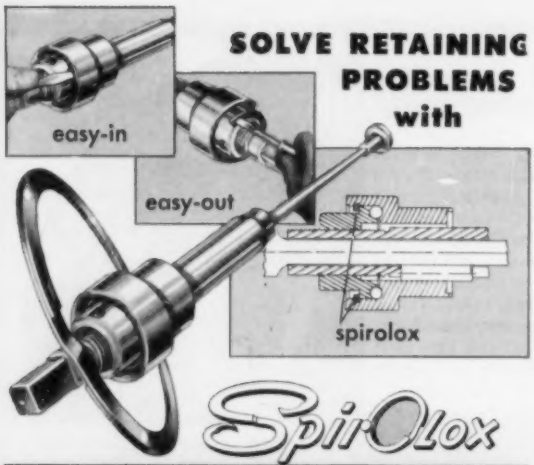

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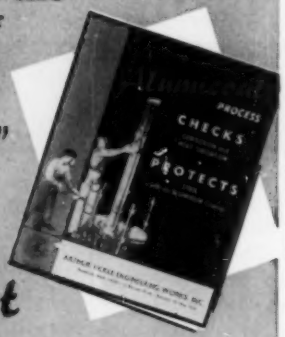

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THE MAN WE MEAN IS A COMPOSITE of the editorial staff of this magazine. For, obviously, no one individual could ever accomplish such a vast business news job. It's the result of many qualified men of diversified and specialized talents.

AND, THERE'S ANOTHER SIDE TO THIS "COMPOSITE MAN," another complete news service which complements the editorial section of this magazine — the advertising pages. It's been said that in a business publication the editorial pages tell "how they do it"—"they" being all the industry's front line of innovators and improvers—and the advertising pages tell "with what." Each issue unfolds an industrial exposition before you — giving a ready panorama of up-to-date tools, materials, equipment.

SUCH A "MAN" IS ON YOUR PAYROLL. Be sure to "listen" regularly and carefully to the practical business information he gathers.

McGRAW-HILL PUBLICATIONS

over 65 floors will be combined in a compact, single-story manufacturing layout. The plant will include a large two-story office building, and research and development laboratories.

In addition to providing dial telephone and other equipment to some 4,800 independent telephone companies that serve approximately two-thirds of the geographic area of this country, Automatic Electric produces telephone type relays, switches and other devices that are used in electrical control and the automation of machines and processes. The company was established in 1891, and is the originator of the dial system of telephony.

National Cash Register Dedicates West Coast Electronics Division

The National Cash Register Company dedicated its modern Electronics Division recently at Hawthorne, California in ceremonies featuring an address by Stanley C. Allyn, president of NCR. The company's Electronics Division was established at Hawthorne three years ago.

The 52,000 square-foot structure is devoted entirely to research and design activity in advanced electronic computers and auxiliary equipment for business systems. Computers designed in the new facility will be capable of performing highly complex data processing work. Their versatility will make them adaptable for use in conjunction with National cash registers, adding machines and accounting machines now in service in more than 90 countries.

Explaining the role of automation in business, Mr. Allyn pointed out that there is an impending revolution in the keeping of records and operation of offices. "Office routines," he remarked, "are on the verge of the most sweeping changes since the advent of the cash register and the adding machine in the late 1800's."

Foremost among the factors causing this revolution, is the rapid advance in clerical costs as a result of the rising wage level and the mounting burden of paper work. While at the turn of the century only one employee in 40 was a "paper" worker, today there is

(Continued on page 397)

LIFT

the efficiency of your hydraulic unit with Roper dependable Pumps. Get optimum performance from the pumps that feature just two moving parts — equal size gears operating in a sturdy case with proper clearance for superior service and long life. The models shown are representative of standard Roper pumps suitable for most applications.

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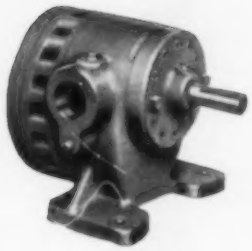
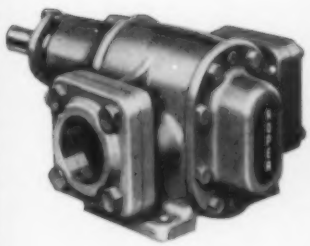


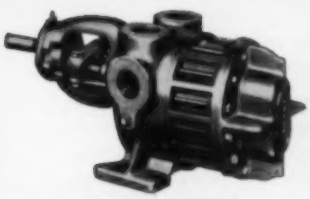
LOWER

maintenance costs with a Roper. For instance, a pump like the Series H with pressures to 1000 P.S.I., sizes 10 to 75 G.P.M. is ideally suited for hydraulic mechanisms and for other applications requiring high pressures. Spur gears run in axial hydraulic balance . . . bearings and bronze wear plates reduce friction under heavy loads. Available with packed box or mechanical seal.

PUSH

the unit in your hydraulic circuit with the correct size Roper for the particular job. In many cases the Series K will do, for it is rated from pressures to 150 P.S.I., capacities ¾ to 50 G.P.M. This model is compact, sturdy . . . is self-lubricated by liquid pumped . . . handles total suction lifts up to 25 feet. Comes with packed box or mechanical seal . . . with or without relief valve.





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favorable comment on a wise choice when you install a Roper as original equipment. Among the dependable Ropers is the Series P Pump — pressures to 300 P.S.I., sizes 1 to 300 G.P.M. It features four-port design with 8 optional piping arrangements . . . supplied in standard or stainless steel fitted models. With packed box or mechanical seal; with or without relief valve.

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one clerical employee among every six workers.

Mr. Allyn cited as another factor encouraging business automation the rising economic status of millions of Americans in the middle income group: "During the past 15 years, the number of checking accounts has doubled to 50 million. An estimated 9 billion checks are written each year. There are over 125 million new life insurance policies and millions of new mortgages and installment loan accounts. Electronic systems will dig American business out from its mountain of paper."

NCR's commercial electronics development program has three objectives. First is the adaptation of conventional cash registers and business machines to serve as a means of original entry and input devices for computers. This has been accomplished by equipping these machines with punched tape recorders. Second objective is to produce a complete computing system, consisting of the computer plus all necessary input and output devices and other periphery units. Third part of the program is the thorough survey of system needs in different types of business and the practical application of electronics to their accounting problems.

Electromet Establishes New Development Department

To expand its development program for new products, processes, and markets in the field of ferro-alloys, metals, and metal compounds, Electro Metallurgical Company, a Division of UCC, has established a Product and Process Development Department. The department will concentrate on developing more economical and better technological processes, leading to improvements in existing products or production of new products.

Extensive facilities at Niagara Falls, N. Y., are available to perform development work in open arc smelting and production, vacuum technology, submerged arc smelting, chemistry and electro-chemistry, electrothermics and pyrometallurgy, particle technology, hydrometallurgy, and engineering development. The department will de-

(Continued on page 399)

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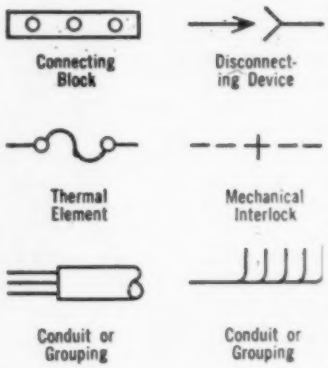


Now you can help achieve industry-wide agreement on graphical symbols for electrical components. As you know, different groups have in the past advanced various proposals for standardization. But while many suggestions had merit, often forgotten was the fact that the symbols must be simple.

For this reason we have collected and reprinted, in an easy-to-use folder, the simplest-to-draw and most readily understandable symbols available. They are based mainly on the Engineering Drafting Standards of the Ford Motor Company, and are supplemented by standards data from the American Standards Association and from the National Machine Tool Builders Association.

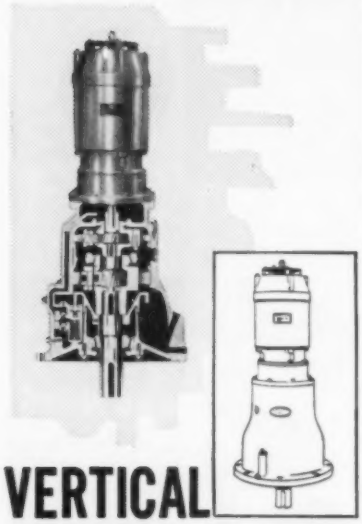
To order a supply of these folders for you and your associates, write or call our Reader Service Department today. Copies are only 15¢ each.

Product Engineering

McGraw-Hill Building
New York 36, N. Y.

Philadelphia

MOTOREDUCER



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For a compact, neat and sturdy self-contained Vertical Speed Reducer, the Philadelphia **MotoReduceR** is tops in design, construction and operation. The unique single casing and bolted-on motor construction . . . makes mounting and installation very simple, and of course, it eliminates base plates and couplings. The planetary, in-line reduction gears provide a rugged drive capable of withstanding severe overload conditions . . . Other features are: wide bearing span, permitting use of long, unsupported vertical shafts; Exclusive "dry-well" construction, which prevents oil leaking down output shaft.

Philadelphia MotoReduceRs can be supplied for output speeds from 9 R.P.M. to 420 R.P.M. with standard motor speeds . . . Units up to 100 H.P. are available—and a full range of horizontal units can also be supplied.

For complete information, send for 32 page Catalog MR-54

phillie gear

PHILADELPHIA GEAR WORKS, INC.
ERIE AVE. & G STREET, PHILADELPHIA 34, PENNA.
Offices in all Principal Cities
INDUSTRIAL GEARS & SPEED REDUCERS
LIMITORQUE VALVE CONTROLS
FLUID AGITATORS • FLEXIBLE COUPLINGS
Virginia Gear & Machine Corp. • Lynchburg, Va.

velop and evaluate products and processes originated by Electromet's Metals Research Laboratories and carry them through pilot plant and evaluation stages until they are ready for full plant-scale operation.

Styrene Supply Expanded By Firestone Addition

The Firestone Tire & Rubber Company will build a 75,000 ton-capacity plant for the manufacture of styrene at its 1000 acre petrochemical manufacturing center near Orange, Texas, Harvey S. Firestone, Jr., Chairman, announced recently. "This chemical plant is scheduled to produce the styrene required by the Firestone Company in its manufacture of synthetic rubber," Mr. Firestone said. "By establishing its own manufacturing facilities for both styrene and butadiene," Mr. Firestone said, "our company becomes the first in the rubber industry to produce the principal raw materials for the manufacture of its synthetic rubber."

Mr. Firestone disclosed that the new styrene plant will be located adjacent to the Company's recently announced 40,000 ton-capacity butadiene manufacturing plant which is scheduled for completion early in 1957. The plant will be in operation early in 1958.

A. O. Smith Expands Electric Motor Division

Plans for immediate construction of a new $350,000 administration building are announced by the Electric Motor Division of A. O. Smith Corporation as the opening phase of a two-year expansion and re-equipment program expected to cost $3,250,000. Other major portions of the expansion of the Division's operations at nearby Tipp City, Ohio, include: A manufacturing plant addition costing nearly $1,000,000 to be started in 1957, and nearly $2,000,000 in new machinery and equipment to be installed in 1956 and 1957.

Effect of the expansion will be a 50 per cent increase in the Electric Motor Division's productive capacity,

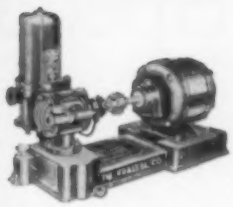
(Continued on page 401)

KRAISSL

Since 1926. In the application, design and manufacture—pumps, separators, hydraulic accessories

EQUIPMENT FOR FLUID POWER TRANSMISSION

Primary Oil Pumps • Vacuum Powered Transmission and Low Pressure Air Service • Air and Liquid Filters •



Rotary Air Pumps for vacuum bottling

Kraissl's patented, automatic, force-free lubrication and flushing system makes these direct - drive, high-capacity pumps ideal for the special requirements of bottle-filling machinery.

Air - cooled design — or water - cooled models for heavier duty.

Class 21-roller-action pumps are recommended for handling corrosive gases and extraneous matter that might jam with closer clearances. The multi-blade design if the Class 25 pumps gives higher capacity efficiencies and is designed for applications requiring higher degree of vacuum. Where water - cooling is desired for continuous service, the water-jacketed Class 25-WJ models are recommended.

EXCLUSIVE CLASS 26 AIR FILTER

is available as an integral part of each pump up to 10 cfm — to produce oil-free discharge air and also conserve the lubricating oil.

WRITE TODAY FOR Bulletins A-1289 and A-1523

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289 Williams Ave., Hackensack, N. J.

Important! Specify TEFLON® by its properties!

TEFLON *can* provide extraordinary physical, electrical, and chemical properties, but these properties *cannot* be taken for granted.

The method used to convert Teflon powder into finished rods, sheets, and tubes greatly affects the quality obtained. This quality, in turn, governs the properties of the end product.

So to *assure* performance, actually specify not only Teflon but also the important *properties* required.

Two grades of Fluoroflex®-T deliver the *optimum* properties you specify for Teflon.

(1) "Electrical grade" Fluoroflex-T is certified to conform to all important electrical and physical properties. It meets the most critical requirements.

(2) A more economical "mechanical grade" satisfies all chemical and thermal needs and offers up to 50% greater resistance to elongation under mechanical loads.

Both grades are produced under exacting quality control standards and are stress relieved to insure that machined parts are dimensionally stable.

Send for data or better still tell us what specific properties are important for your application.

® *Teflon is a DuPont trademark. Fluoroflex is a Resistoflex trademark.*

RESISTOFLEX

CORPORATION • **Roseland, N.J. Western Plant: Burbank, Calif.**

Warehousing Distributors: Western Fibrous Glass Products, Los Angeles, Calif.; F. B. Wright Co., Detroit, Mich.; Colonial Kolonite Co., Chicago, Ill.; Industrial Safety Supply Co., Hartford, Conn.; Lone Star Rubber Co., Houston, Tex.; Flow Products, Inc., Chicago, Ill.

CABLE CLIPS

★ *of all Nylon* for severe conditions ★ *of Ethyl Cellulose* for maximum economy

WECKESSER

molded Black Nylon **SCREWS and NUTS**

★ Acid resistant
★ Need no insulation
★ Can't rust
★ Can't corrode

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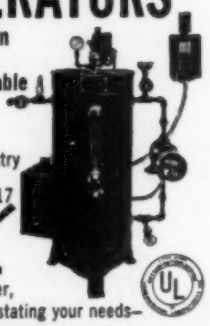
When you need a compact, portable, electrically operated source of

HIGH or LOW Pressure STEAM

HOT SHOT SUSSMAN T.M.

ELECTRIC STEAM GENERATORS

are available in all sizes—for every conceivable purpose!



Used by the leaders of industry throughout the world—Since 1917

Ask your supplier, or write direct stating your needs—

AUTOMATIC SUSSMAN STEAM PRODUCTS CORP.

140 West 31st St., New York 1, N. Y. BR. 9-9736

according to D. L. Mills, Division, general manager. The division makes special purpose lines of fractional integral and hermetic electric motors ranging in horsepower from one quarter to 125. Much of the new equipment will consist of a higher degree precision machinery designed to improve methods and to offer the Division's motor customers a higher quality product. The expansion also will increase employment by several hundred persons and unite present administrative, accounting, engineering and laboratory staffs under one roof. Plants and offices now are scattered in Tipp City and Dayton.

Cornell Aeronautical Laboratory Continues Wind Tunnel Modifications

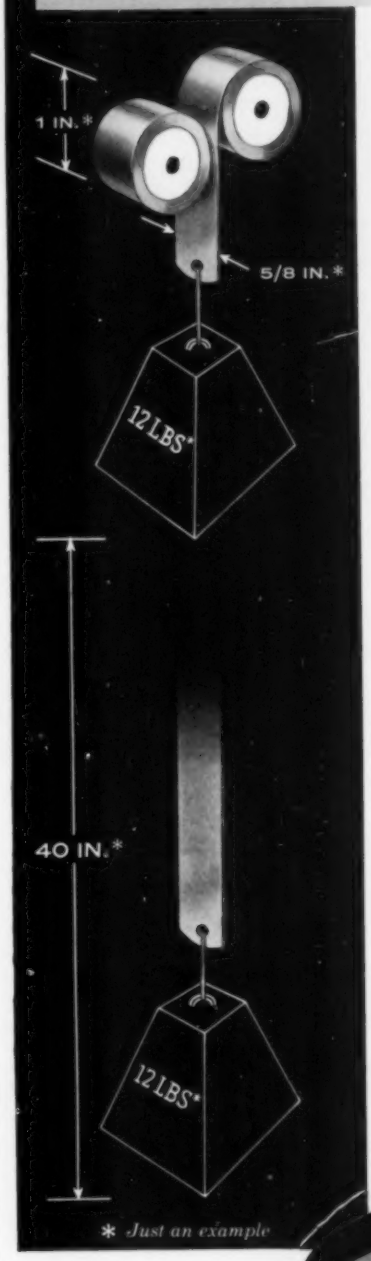
The large wind tunnel at Cornell Aeronautical Laboratory, Inc., will shut down July 3 for three months, Robert S. Kelso, wind tunnel head, announced recently. New equipment will be installed and tested and further alterations will be made for the $2,000,000 modification program which is expected to be completed late this year.

When modifications are finished, the tunnel will have an 8 x 8-foot transonic test section which will operate from Mach 0 to 1.30 (about 0 to 950 mph at sea level). The facility will permit accurate testing of airplanes, missiles and components at speeds slightly below, at, and slightly above the speed of sound. This speed range is the one most essential for current aircraft.

Meanwhile testing continues in the 8½ x 12-foot variable density wind tunnel. Nearly 400 hours of testing, mostly for the military, are being completed this month. Tests were recently finished on a model of the propeller and engine nacelle of the Lockheed Electra turbo-prop transport.

Propeller research in the 8½ by 12-foot wind tunnel has been carried on since 1952 when the Laboratory's propeller dynamometer, developed with Air Force funds, became available. The test facility provides up to 2000 horsepower to model propellers 4, 5 and 6-feet in diameter at rotational speeds up to 8000 rpm.

BALANCE IT *with a*
NEG'ATOR® *constant-force spring*



* *Just an example*

NEG'ATOR is the name of a new kind of spring—the coiled-band spring that extends many times its original size without the increasing force common to conventional springs.

One of the natural uses of the NEG'ATOR Spring is counterbalancing without mass—vertically as illustrated, or horizontally. Using the NEG'ATOR Spring, the design engineer can eliminate dead weights or linkages and gain space, freedom of motion, reduced over-all weight, simplified assembly.

For example, each of the NEG'ATOR Extension Members used back-to-back in the illustration measures about 1 inch in diameter when coiled. They will counterbalance a 12 lb. weight over about 40 inches of travel. The only force required to move the weight is that required to overcome friction in the mechanism. There is no intercoil friction in the NEG'ATOR Spring.

NEG'ATOR Springs in extension or motor form are versatile in counterbalancing functions—are now being used to balance light tank floats in sensitive liquid-level indicators and fire doors and other heavy equipment. Extensions range to over 20 feet.

Used as an extension spring, a motor, band, clamp, or clip—this revolutionary new *constant-force* component upsets all previous spring principles, opens a whole new field of mechanical design by doing what springs have never done before.

These and other functions of Hunter NEG'ATOR constant-force springs are described in Bulletin 310N, "The Story of the NEG'ATOR Spring." Send for a copy.

HUNTER SPRING COMPANY
5 Spring Avenue, Lansdale, Pennsylvania
SPRINGS • STAMPINGS • TEST APPARATUS

J. D. ZELLERBACH

Portrait by Fabian Bachrach

"Good business is for everybody...

"At Crown Zellerbach we have 24,000 employees who, like the company, have bills to pay, plans to finance, and emergencies to anticipate. This requires saving.

"Crown Zellerbach saves a portion of its annual income in U. S. Government securities. This saving is safe, systematic and, with interest, profitable. Our employees follow the same 'Good business' practice through the Payroll Savings Plan.

"At our Camas, Washington, paper mill, for instance, 1,654 employees out of a total of 2,640 set aside a portion of their income last year and bought over $450,000 worth of U. S. Savings Bonds on the Payroll Savings Plan. To them this means money for the goods of today, the ambitions of tomorrow, and the security of the future. And this way of saving has the same advantages for an individual as for a company—a safe investment, a convenient method, and a profitable return.

" 'Good business', then, is not just for business. 'Good business' which includes systematic saving in Government bonds is for everybody."

J. D. ZELLERBACH, ***President***
Crown Zellerbach Corporation
Chairman, Committee for Economic Development
Chairman, National Manpower Council

If you do not have the Payroll Savings Plan . . . or if you have the Plan and employee participation is less than 50% . . . write to Savings Bond Division, U.S. Treasury Department, Washington, D. C. Your State Sales Director will be glad to help *you* express your agreement with Mr. Zellerbach..."Good business is for everybody."

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Product Engineering

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The Advertisements in this section include all employment opportunities—executive, management, technical, selling, office, skilled, manual, etc.

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Positions Wanted
Part Time Work

Civil Service Opportunities
Selling Opportunities Wanted
Selling Opportunities Offered

Employment Agencies
Employment Services
Labor Bureaus

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Box Numbers—counts as 1 line.

Position Wanted ads are ½ of above rate.

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Send NEW ADS to Classified Advertising Div. of PRODUCT ENGINEERING, P. O. Box 12, N. Y. 36, N. Y., for August issue closing July 17th

memo to

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LINDE is seeking

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electric welding,
flame processes,
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only minutes away from pleasant residential areas—excellent schools for children—ideal for the young engineer with a family. Please send resume to:

Development Laboratory, Dept. PE 7

LINDE AIR PRODUCTS CO.

A Division of Union Carbide and Carbon Corporation

P.O. Box 819 Newark 1, New Jersey

WANTED! EXPERIENCED REINFORCED PLASTICS ENGINEERS

Are you looking for a permanent position of responsibility where your skill and ability in the development of new reinforced plastic materials, processes and products will be recognized? If your interest and experience is in this field of important engineering endeavor, you may qualify for one of the openings now available at Boeing Airplane Company. In addition to the advantages of achieving professional recognition and advancement, you will be eligible to pursue advanced studies with company assistance in tuition. Also there is a liberal travel reimbursement plan, two weeks paid vacation each year, and a company-sponsored retirement plan.

For additional information concerning these positions, send your resume today to:

JOHN C. SANDERS
STAFF ENGINEER—PERSONNEL

BOEING AIRPLANE COMPANY

DEPARTMENT EP-2 **SEATTLE 24, WASHINGTON**

ADVERTISING MAN WANTED FOR TECHNICAL PRODUCTS

Previous advertising experience not necessary but helpful. Must have at least two or three years of college with courses in engineering and technical subjects and like to write. If you have the qualifications we have an opportunity open for you. Man selected will be trained in all phases of industrial advertising. In your letter of application state age, education, positions held, and give statement of why you want a career in advertising. Location: well-known Connecticut company.

P-1211, Product Engineering
330 W. 42 St., New York 36, N. Y.

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One of the largest industrial design organizations in New York has an opening for a sales executive to contact nationally known manufacturers regarding product styling. He should have the following background and characteristics:

Substantial experience in marketing, advertising, and merchandising. Knowledge of materials and manufacturing techniques and ability to use this experience effectively. Creative, imaginative and inventive, yet practical. Able to verbalize ideas rapidly whether oral or written.

Ability to understand motives of others and to size up complicated human relations situations. Enjoy contact work and find persuading others rewarding. Able to work with sustained concentration and to pay proper attention to both details and the overall aspects of the job. An effective organizer and administrator able to grow into a position of top level responsibility and decision making.

Our staff knows of this ad. Replies will be held in strict confidence.

P-1581, Product Engineering
330 W. 42 St., New York 36, N. Y.

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New Product Design

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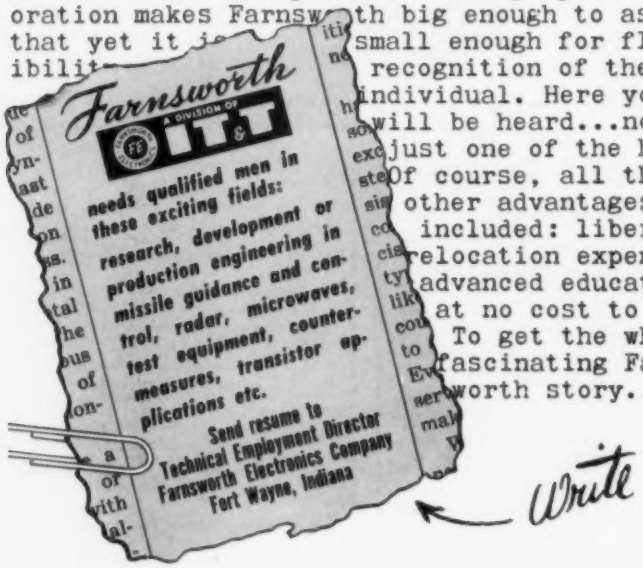
I am attach... snapshot of ou... in the country ... close to schools, chu... ... only eight minutes from the ... offices. This is only one ... reasons why most of the folks who come here for an interview just stay...wire the wife to start packing... knowing she will love the living part of it.

Now about the work and the people.... The attached clipping will give you a brief idea of some of Farnsworth's activities for the military and industry in the fields of electronics and nuclear energy. Your associates will be eminent scientists and engineers with many "firsts" to their credit in electronics. (Like Philo Farnsworth, our Technical Director and the inventor of electronic television.)

And don't worry about permanency or stability. Being a member of the world-wide International Telephone and Telegraph Corporation makes Farnsworth big enough to assure that yet it is ... small enough for flexibility ... recognition of the individual. Here you will be heard...not just one of the herd. Of course, all the other advantages are included: liberal relocation expense, advanced education at no cost to you. To get the whole fascinating Farnsworth story...


Farnsworth
A DIVISION OF IT&T
needs qualified men in these exciting fields:
research, development or production engineering in missile guidance and control, radar, microwaves, test equipment, countermeasures, transistor applications etc.
Send resume to
Technical Employment Director
Farnsworth Electronics Company
Fort Wayne, Indiana
Write

NEED

?

DESIGN ENGINEERS

?

They—and their assistants—are the readers of this magazine. You can hire them by placing a "position vacant" advertisement where they are sure to see it—in our Employment Opportunities section.

PRODUCT ENGINEERING

Classified Advertising Division

To tap this manpower market, just send in your advertisement before July 17 directly to us at P. O. Box 12, N. Y. 36, N. Y.

DESIGN ENGINEER

MINIMUM QUALIFICATIONS:
DEGREE + 8 YEARS' EXP

Profit sharing without investment.
Liberal fringe benefits.

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PERSONNEL DIRECTOR
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P O Box 350
Worcester, Mass.

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A well established, progressive manufacturer of business forms, mechanical and electronic auxiliaries to business machines, and a leader in Office Automation has permanent positions available in these areas: electromechanical, tool, machine and mechanical product design. Excellent employee benefits and advancement opportunities. All replies kept in strict confidence. Send resumes to: Professional Employment, The Standard Register Co., Dayton 1, Ohio.

CHIEF PRODUCT ENGINEER
$10,000 plus Bonus

Excellent opportunity for an engineer with broad tooling experience. Company manufacturing a wide variety of products seeks a man to take charge of its product design. Send resume to:
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6 N. Michigan Ave., Room 708
Chicago 2, Ill.

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Tremendous opportunity for creative man with administrative ability.
Starting salary $12,000-$15,000. Company pays agency fee, relocation expense. Replies held in strictest confidence.
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Qualified designers and engineers to work in the design and development of electrical automotive components. Excellent salary and liberal fringe benefits as well as stock participation plan. Write or apply at: Ford Motor Company, #2 Stewart Street, Ypsilanti, Michigan.

Wanted! Experienced reinforced plastics engineers. Are you looking for a permanent position of responsibility where your skill and ability in the development of new reinforced plastic materials, processes and products will be recognized? If your interest and experience is in this field of important engineering endeavor, you may qualify for one of the openings now available at Boeing Airplane Company. In addition to the advantages of achieving professional recognition and advanceent, you will be eligible to pursue advanced studies with company assistance in tuition. Also there is a liberal travel reimbursement plan, two weeks paid vacation each year, and a company-sponsored retirement plan. For additional information concerning these positions, send your resume today to: John C. Sanders, Staff Engineer—Personnel, Boeing Airplane Company, Department EP-1, Seattle 24, Washington.

Designer to join young progressive machinery manufacturing company located in Charlotte, N. C. Education secondary to proven ability. 10 to 15 years practical drafting and design experience essential. Must be capable of handling varied design problems such as ferrous and non-ferrous castings, sheet metal fabrication, mechanisms, machined parts, etc., and to do liaison work between project engineers and shop personnel. Send resume stating full particulars including salary expected to Employment Manager, P. O. Box 8336, Charlotte, N. C. All replies confidential.

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Electronic & Mechanical
PHYSICISTS:

Top Grade Openings

At Melpar *Leader in Electronic Research & Development*

Due to our continuing expansion program, a number of top grade openings exist in our new laboratories suburban to Washington, D. C. We urge you to consider the following:

1. At Melpar the engineer is not tied to a pre-arranged schedule of advancement. Instead, promotion and advancement are based on *individual recognition*, where skill and ability are the paramount factors of determination.

2. Melpar has doubled in size every 18 months for the past 10 years. New openings occur constantly. This enables the engineer to advance to positions of increased responsibility ***as soon as he is ready.***

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4. Our new air-conditioned laboratories encompass over 285,000 square feet and offer *complete* facilities for creative research and design. In addition to our central Model Shop, supplementary facilities, personnel and test equipment are available for *immediate* use within each project group.

5. The Northern Virginia Area, suburban to Washington, D. C., in which Melpar is located, offers excellent living conditions, enjoys the Nation's highest per capita income, fine homes and schools. Recreational, cultural and educational facilities abound. Fully-accredited graduate courses are offered at the Melpar laboratories and at 5 universities in the Area.

Top Grade Openings Exist in These Fields:

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Write for complete information. Qualified engineers and physicists will be invited to visit Melpar at Company expense.

Write: Technical Personnel Representative

MELPAR *Incorporated*
A Subsidiary of Westinghouse Air Brake Company
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***Positions also available at our laboratories in:** Cambridge, Mass., 99 First St., Watertown, Mass., 11 Galen St.*

ENGINEER

Does your present position contain any elements of these activities?

- Mechanical Development
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- Stress and Vibration Analysis
- Instrumentation Engineering

A few openings for engineers with 2 or more years experience in these areas and the ability to apply their basic knowledge effectively to concepts in advance aircraft engine design and development.

These opportunities are outside the usual run of engineering positions, with well defined promotional possibilities in a department of a long-established company, where expansion has been continuous. Remuneration is commensurate with the advanced nature of the assignments. The engineer is accorded high professional status and there are additional benefits of satisfying nature. The location in a Northeastern resort area is marked by exceptional cultural and recreational advantages. The product offers stability in its appeal to both commercial and military markets.

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Box Numbers—Care of publication count as one line.
Discount of 10% if full payment is made in advance for 4 consecutive insertions.
Equipment Wanted or For Sale Advertisements acceptable only in Displayed Style.

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- Magnetic devices, synchro, servo, control components, specific-performance motors, from appliance drives to automation instruments.
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UNIQUE OPPORTUNITY

- - - - for Mechanical and Chemical engineers with creative talent and business judgment.

If interested in this really unusual opportunity, submit complete resume including education (approximate academic standing) and experience to:

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a division of
UNION CARBIDE AND CARBON CORPORATION

P. O. Box 8237 Indianapolis 24, Indiana

Attention: Mr. J. J. Rostosky
Refer to ad: PE-PD

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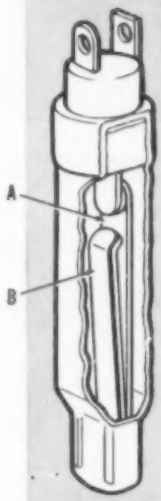
HOW CHACE THERMOSTATIC BIMETAL ACTUATES the FASCOSTAT

A Product of Fasco Industries, Inc. Rochester, N.Y.

The diminutive Fascostat, manufactured by Fasco Industries, Inc., is used in one of its application s as a motor protector in shaded pole motors for air conditioning equipment, furnaces, etc. Normally closed, the thermostat is calibrated to open when an unusual condition causes the motor to overheat. Of course, the Fascostat is dependent on its Chace Thermostatic Bimetal element for positive operation and continued accuracy.

Here's how it works: the current is carried by the spring arm (A) through normally closed contacts. Adjacent to the spring is the Chace Thermostatic Bimetal element (B). When the motor overheats above 235° plus or minus 5°F, the thermostatic bimetal deflects against the spring, opening the contacts and breaking the circuit. The motor begins to cool until the bimetal closes the contacts. This cycle will repeat until the fault is corrected.



Chace Thermostatic Bimetal is manufactured in 29 types, in strip, coil or completed elements fabricated to your specifications. If your device is actuated by temperature change, write for our *new* 44-page booklet, "Successful Applications of Chace Thermostatic Bimetal," containing interesting uses of bimetal, formulas, calculations and other engineering data.

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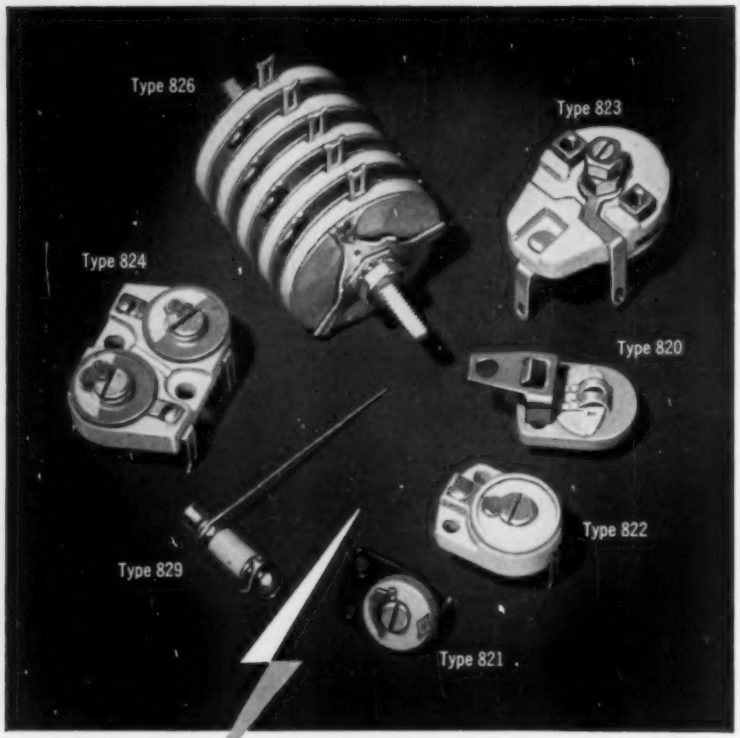

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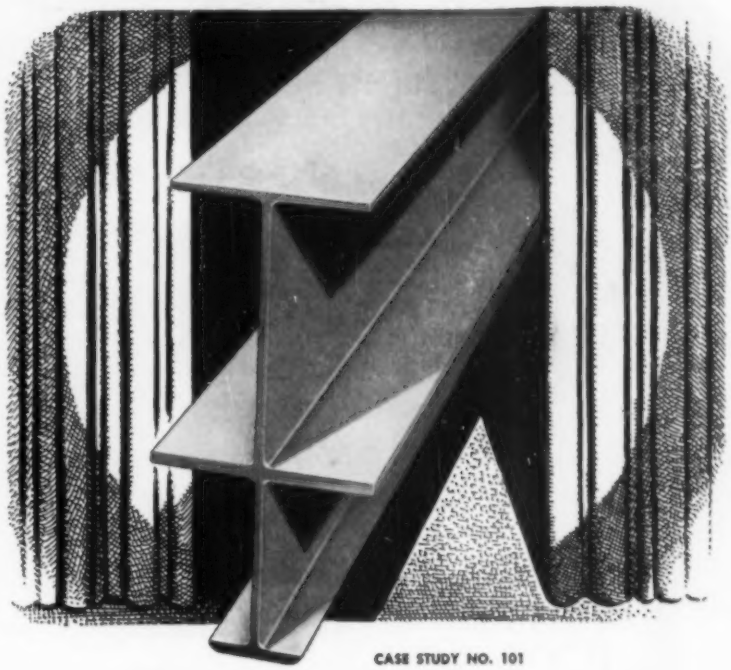
Art Drapery Studios rate repeated curtain calls



CASE STUDY NO. 101

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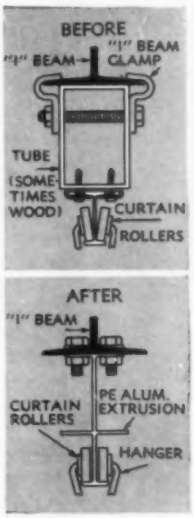

Art Drapery Studios, 2739 N. Racine Ave., Chicagoland designers and installers of stage curtains and gymnasium dividers, had a track problem—and tracks are an important part of any job they do. Over-all costs were high because of drilling, assembling, splicing, and installation operations.

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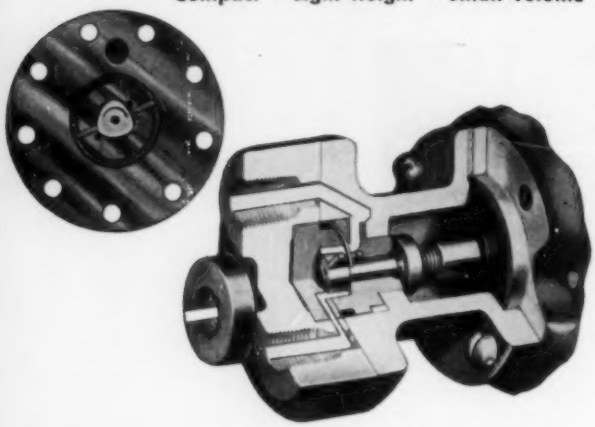

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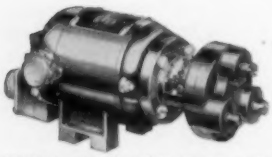
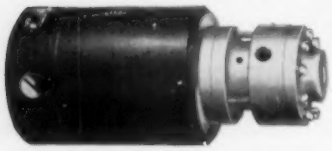
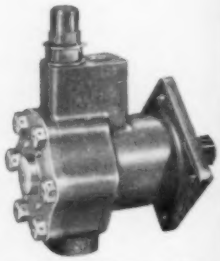


STYLE A—Single inlet double outlet type aircraft pump



STYLE C—Industrial pump



STYLE F—Engine driven fuel pump

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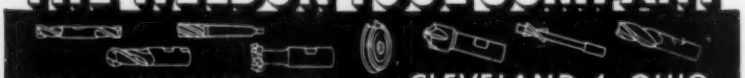

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new low in cost

This combination of Consolidated's 6-channel 5-117 Recording Oscillograph and 8-110 Bridge Balance fills the long-standing gap between pen-type recorders and complex oscillograph/amplifier systems . . . provides high-speed, graphic records of physical phenomena invaluable in research and development, product analysis, and clinical diagnosis. Stress, strain, vibration, pressure, temperature . . . measure them all at the same time for a *true picture* of either a product or a patient. The system is so simple to operate that no special electronic experience is needed . . . and so light that it can be carried anywhere. You'll find dozens of applications for it in your laboratory, your plant, or your clinic.

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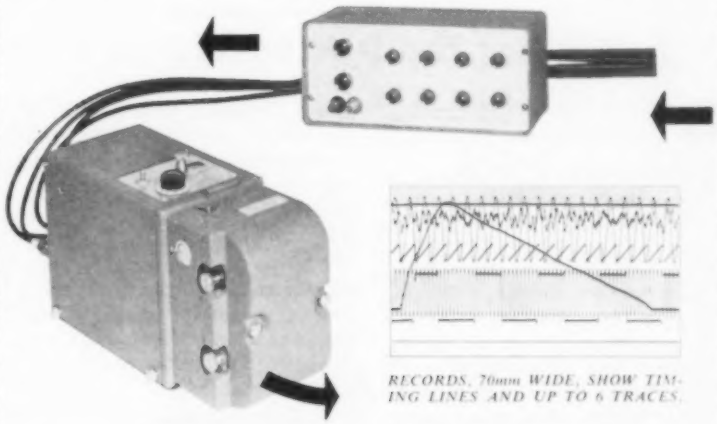

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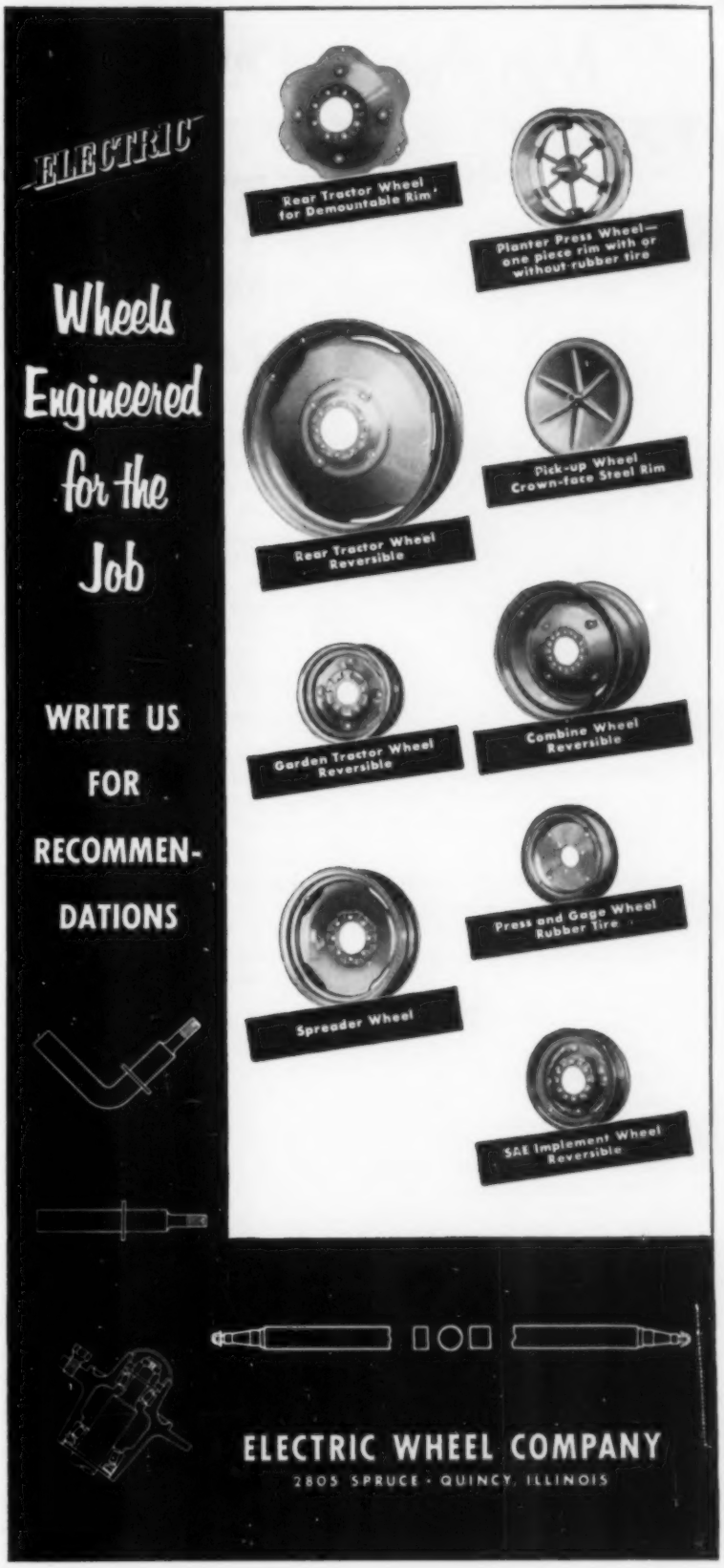
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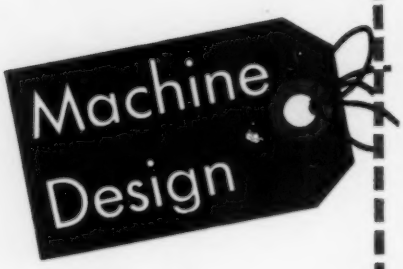

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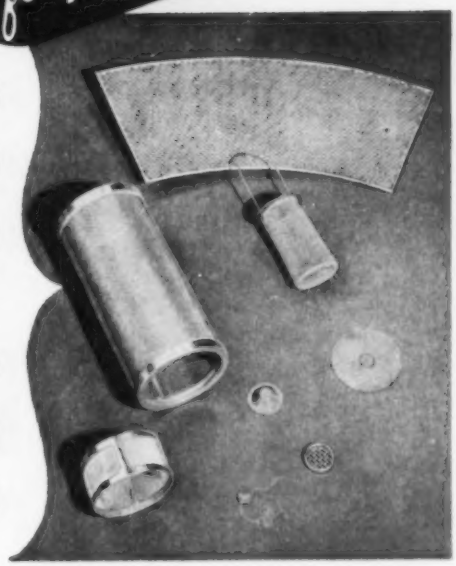

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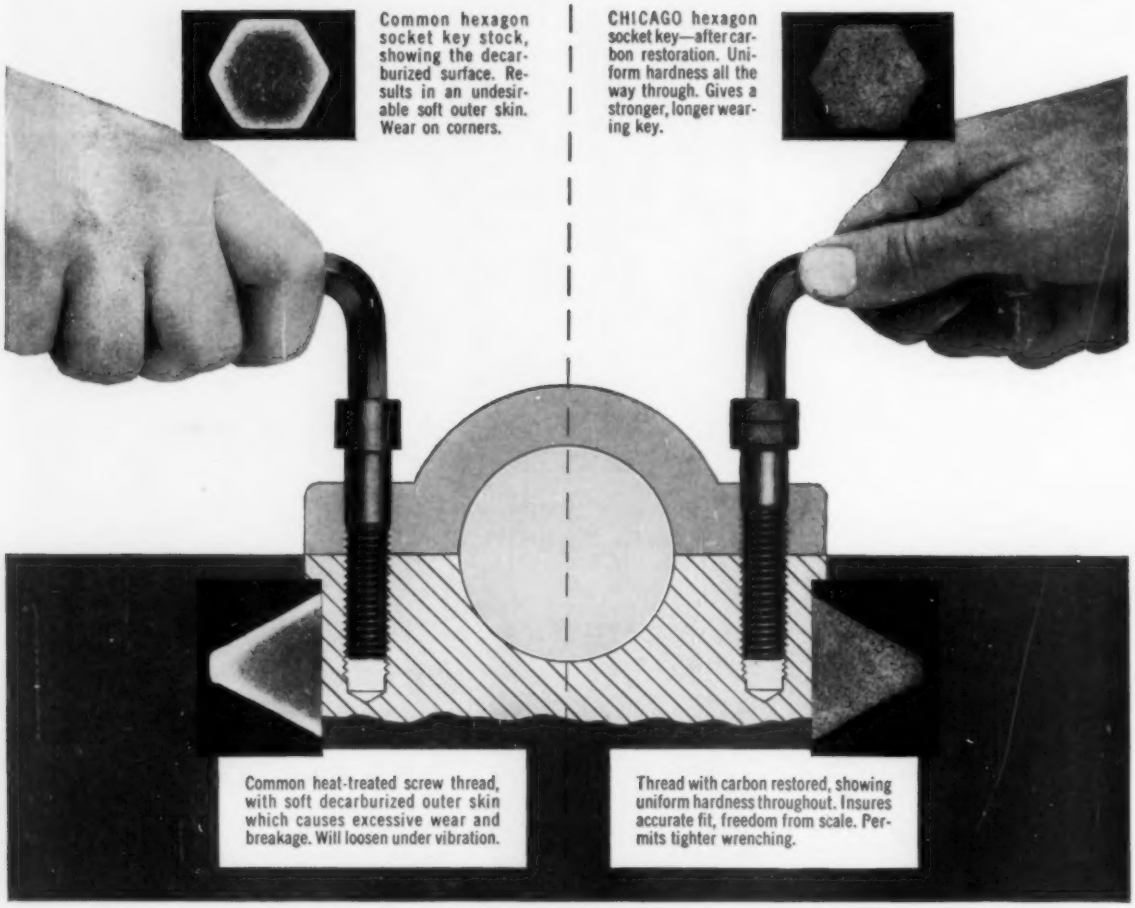
How carbon affects fastener performance

Screw fasteners may look identical, but the microscope reveals a wide difference in their ability to "take it"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CHICAGO hexagon socket key—after carbon restoration. Uniform hardness all the way through. Gives a stronger, longer wearing key.
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71—Plastic Outlet Box
72—Silent Bin Vibrator
73—Acceleration-Sensitive Switch
74—Printed Card Receptacle
75—Door Interlock Switch
76—Rotary Sector Potentiometer
77—Control Transformers
78—Air Eliminator
79—Self-Locking Anchor Nuts
80—Pressure Reducing Valve
81—Indicates Flow of 1 Gph
82—Transistorized Servo Amplifier
83—Test Jack Eyelets
84—Electrical Timing Meters
85—Automatic Regulator-Lubricator
86—Blower for Low Air Density
87—Condensate Control
88—Fluid Motor-Speed Reducer
89—Oscilloscope Probe and Hood
90—Adjustable Fluid Drive
91—Variable Pitch Motor Pulleys
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95—A Universal Cylinder Mounting
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104—Rack for Drafting Board
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107—Fastenings
108—Bronze Bearings, Bushings
109—V-Belts
110—Plastics
111—Hydraulic Pumps, Valves
112—Right-Angle Gearmotor
113—Vinyl-Metal Laminates
114—V-Belts and Sheaves
115—Compressors
116—Canned Motor Pumps
117—Rotary Gear Pump
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119—Plastic-Impregnated Moldings
120—Miniature Connector
121—Steel Castings
122—Revolution Counters
123—Aluminum Impact Extrusions
124—Stainless Steels
125—Solenoids
126—Electric Motors
127—Speed Reducers
128—Miniature Relay
129—Mechanical Seals
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131—Sensing Devices
132—Solenoid Valves
133—Titanium
134—Ceramic Parts
135—Industrial Wheels
136—Resistors
137—Precision Components
138—Plastics
139—Panel Instruments
140—Polyester Laminates
141—Molding Compounds
142—Sub-Fhp Motors and Blowers
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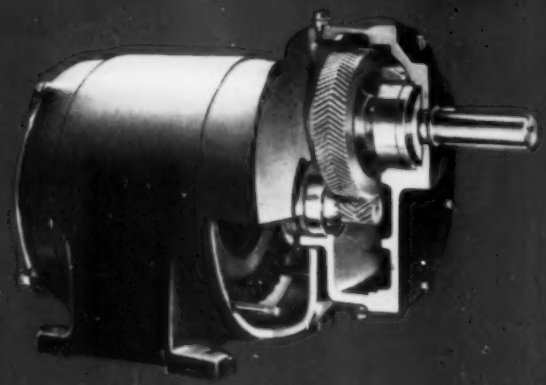

SINGLE REDUCTION
Parallel Shaft Type

MASTER
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Because...

...With five types of parallel and right angle Gearmotors, Master has the flexibility and choice of design you need for selected output speeds.

...With electric motor and gears combined into a compact, integral power unit, you reduce costs and increase efficiency through elimination of belts, couplings, chains, sprockets, external bearings or separate reducers.

...Available in sizes from 1/8 to 125 H.P. You can integrate with the gearmotor electric brakes—3 types of variable speed units and fluid drive in any combination.

...And that's why more gearmotors carry the Master name than all other makes combined. Write on your business letterhead for details.

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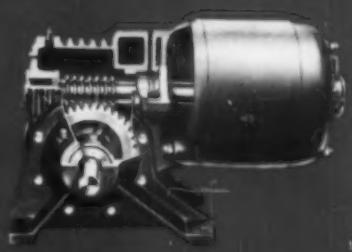


SINGLE REDUCTION
Right Angle Shaft Type

THE MASTER ELECTRIC COMPANY
Dayton 1, Ohio

New Bullard multi-spindle vertical chucking machine combines high precision with high speeds

TO provide lasting precision despite heavy work loads and high speeds, Bullard uses Timken® tapered roller bearings on the lower end of the spindles and on other shafts of its new Mult-Au-Matic Type "L".

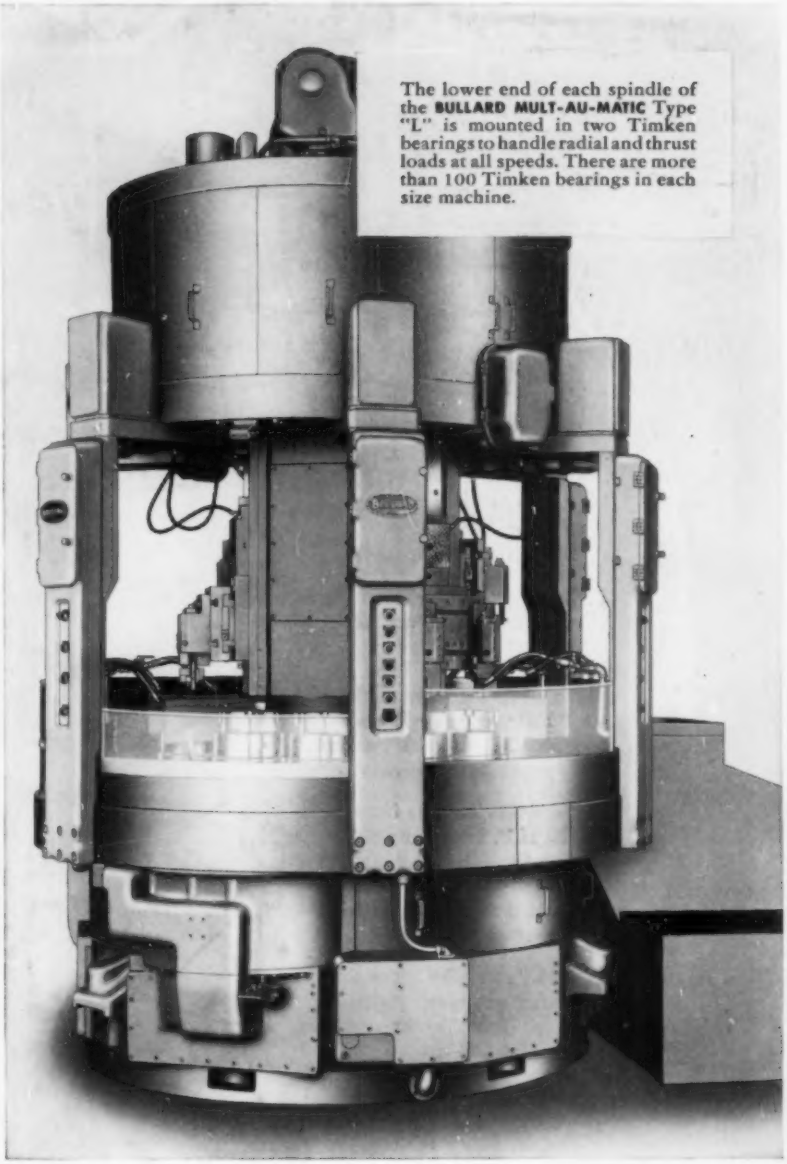
These bearings furnish the precision needed at the locating position at the bottom of each spindle. Full line contact between rollers and races gives Timken bearings extra load-carrying capacity. Their tapered construction takes radial and thrust loads in any combination. Result: shafts are held in rigid alignment; shaft deflection and end-play are minimized; gears mesh smoothly; spindle precision is assured at high speeds.

Timken bearings are geometrically designed for true rolling motion, and precision manufactured to live up to their design.

To insure quality, we even make our own steel. We're America's only bearing manufacturer that does.

So whether you buy or build machine tools, specify Timken bearings. You'll find the trademark "Timken" on every bearing. It's your assurance of high quality. The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ontario. Cable: "TIMROSCO".

This symbol on a product means its bearings are the best.



The lower end of each spindle of the **BULLARD MULT-AU-MATIC** Type "L" is mounted in two Timken bearings to handle radial and thrust loads at all speeds. There are more than 100 Timken bearings in each size machine.

IT'S TIMKEN BEARINGS FOR VALUE!

To get the best value in bearings you may find this simple formula helpful:

$$Value = \frac{quality + service + public\ acceptance}{price}$$

Obviously a big advantage *above* the line gives you more value than a small one *below*. No other bearing can match the uniform high quality, engineering and field service and overwhelming public acceptance you get with Timken bearings.

TIMKEN

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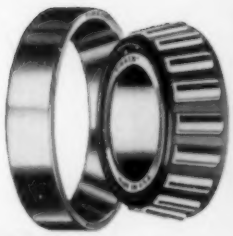
TAPERED ROLLER BEARINGS



NOT JUST A BALL ○ NOT JUST A ROLLER ▭ THE TIMKEN TAPERED ROLLER ▭ BEARING TAKES RADIAL ▯ AND THRUST ▯ LOADS OR ANY COMBINATION